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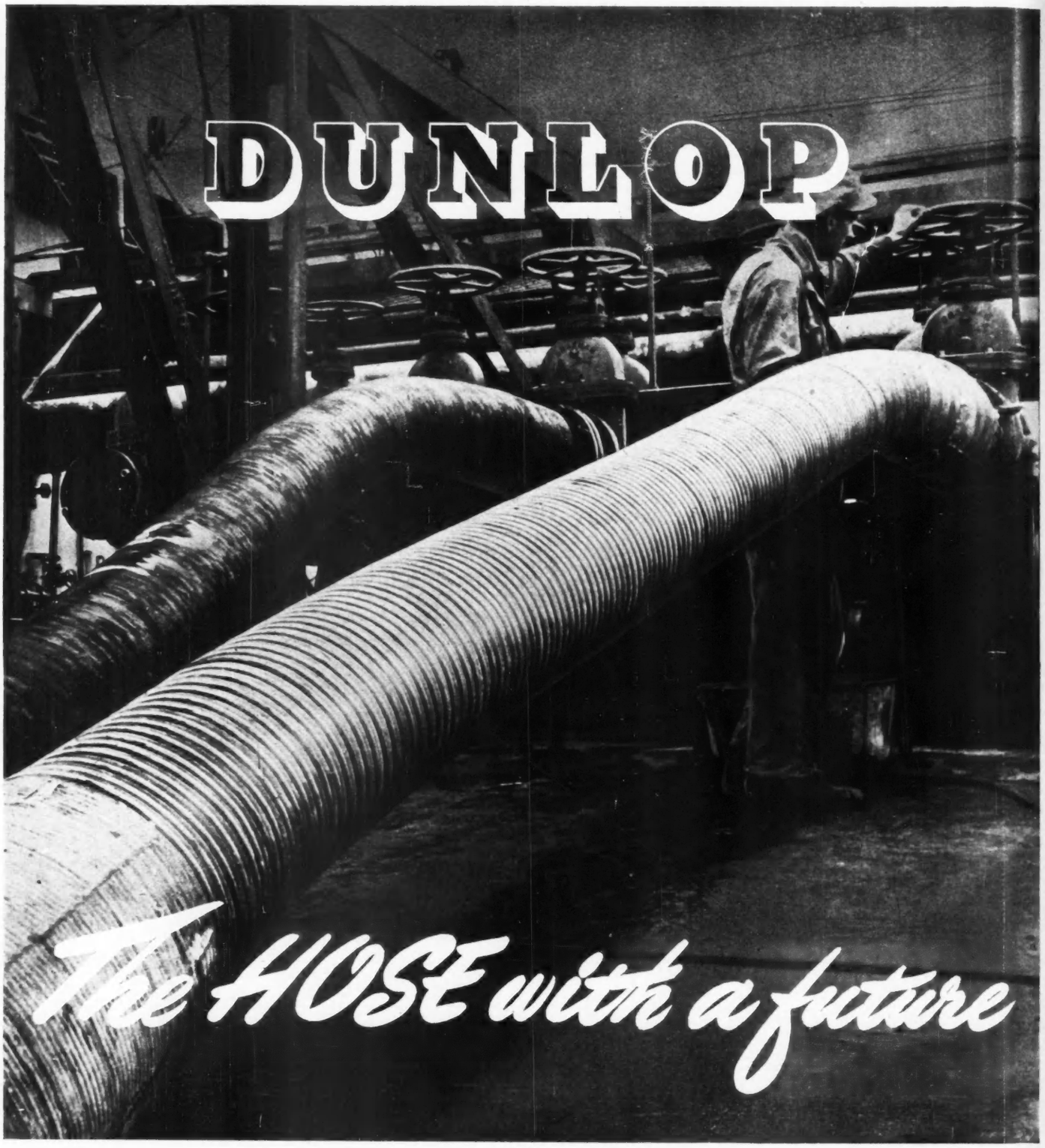

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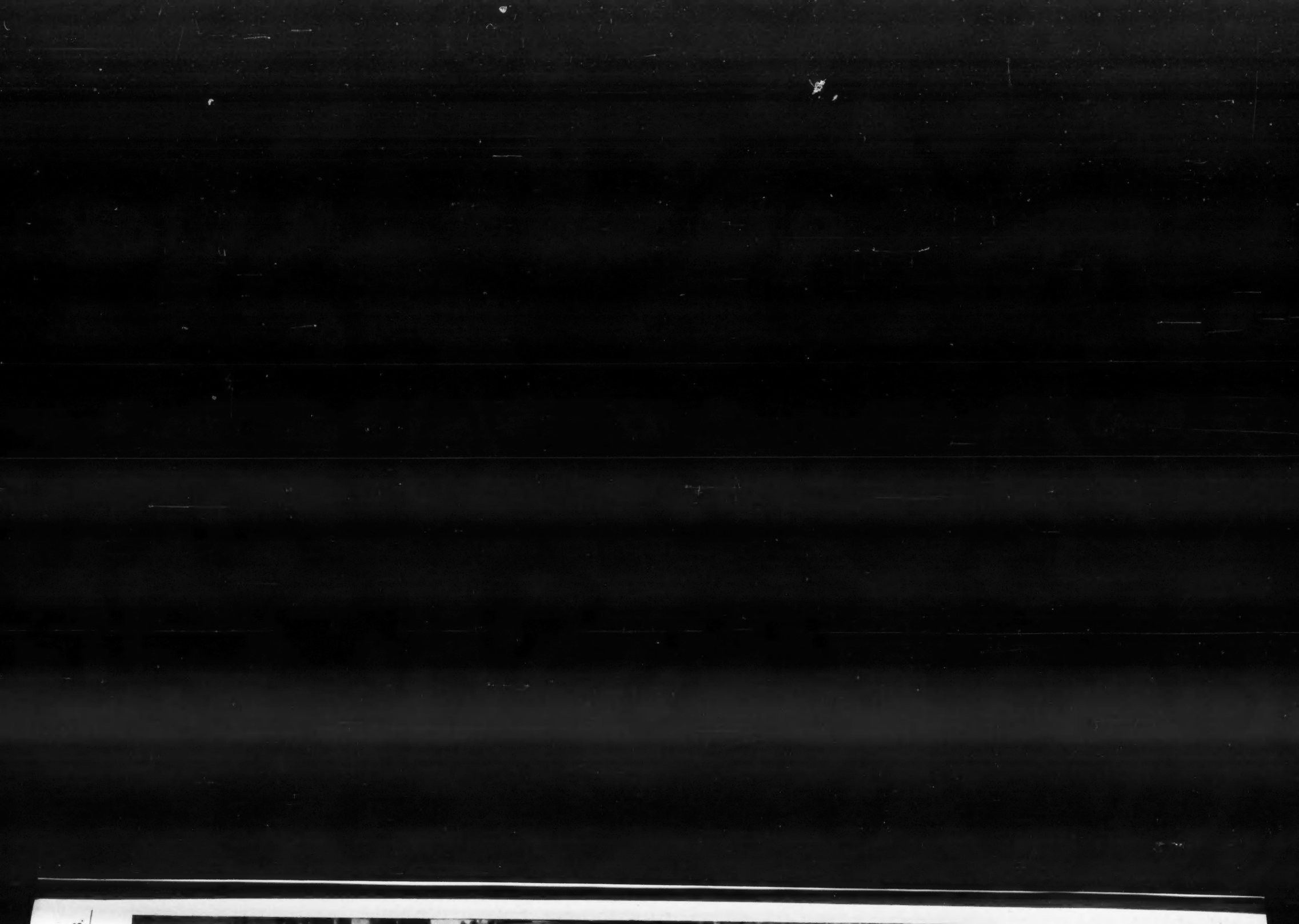


TESTS OF 4-4-4-4 PASSENGER LOCOMOTIVE, PENNSYLVANIA RAILROAD.

By E. C. POULTNEY, O.B.E., M.I.Loco.E.

THE tests of a 4-4-4-4 Class T1 high-speed passenger locomotive of the Pennsylvania Railroad, which were carried out at Altoona, Pennsylvania, in 1944, were described by Mr. Ralph P. Johnson in a paper presented before the New York Railroad Club, in May, 1945. Some further particulars of these tests have been obtained by the author from the late Mr. H. W. Jones, former Chief of Motive Power, Pennsylvania Railroad, and also from Mr. Johnson. It is proposed to give some of the more interesting results of the tests; and although the design of the locomotive, and the developments which preceded it, have been fully described elsewhere, it is advisable to refer briefly to them.

In 1938, a committee of the Association of American Railroads instituted a series of trials, the principal object of which was to determine the drawbar horse-power required to haul a 1,000-ton train at a constant speed of 100 miles an hour on a level track. It was found that 3,379 h.p. was required. An even greater power is necessary, of course, to accelerate trains of this weight with sufficient rapidity to make scheduled speeds of 100 miles an hour a practical proposition. It was therefore calculated from the results of these tests that 7,000 drawbar horse-power would accelerate a 1,000-ton train to 100 miles an hour, 10 miles after starting from rest; and that 5,000 h.p. would accelerate the train to that speed after 33 miles running. One observation on the results of the test is particularly interesting: "Nothing developed in the test to indicate that any of the locomotives had reached the limit of boiler capacity. Therefore, the question of sustained power becomes a question of mean effective pressure. It is evident that, if the mean pressure remains constant as the speed increases, the power will increase with speed, but, as the mean effective pressure for any given cycle of valve events necessarily decreases with speed, the ideal locomotive must have port openings so large, and so accurately timed, that this decrease is kept as low as possible. Obviously, the mean pressure cannot be sustained successfully by lengthening the cut-off. On the other hand, high speeds should be accompanied by short cut-offs." The features of design which govern cylinder performance were then stated to be: high boiler pressure; minimum pressure drop from boiler to steam chests; large steam-chest volume; maximum port openings; and minimum back-pressure. Mr. L. B. Jones, engineer of tests on the Pennsylvania Railroad, enlarged upon these points, and stated that efficient steam distribution required separate admission and exhaust valves, arranged so that cut-off may be shortened without advancing the other events.

The Pennsylvania Railroad were already collaborating with three firms of locomotive builders in the design of a high-power express passenger locomotive; and, as a result of this work, a 6-4-4-6 four-cylinder locomotive, classified S1, and designed to develop 6,500 indicated horse-power, was completed in 1939. The boiler pressure was 300 lb. per square inch, and the engine was provided with 12-in. diameter piston-valves, actuated by Walschaerts motion. The cylinders were 22 in. in diameter and the piston stroke was 26 in. Only one S1 locomotive was built, because it was too large for working over all divisions of the main line. The Pennsylvania Railroad also modified a Class K4s Pacific locomotive by fitting it with new cylinders, and poppet-valves operated by a new form of gear of the Franklin Railway Supply Company. Tests carried out on the track in fast passenger service and on the Altoona testing plant, showed that this locomotive, though equipped with the same boiler (but a larger superheater), could haul heavier trains than when fitted with conventional Walschaerts gear and 12-in. piston-valves, and that the maximum power had been increased from about 3,500 to 4,260 indicated horse-power, for a steam flow of approximately 70,000 lb. per hour.

Orders were placed by the Pennsylvania Railroad in July, 1940, for two locomotives to a design prepared by the Baldwin Locomotive Works. The locomotives are known as Class T1, and have a 4-4-4-4 wheel arrangement; the wheelbase is shorter than that of the S1 locomotive, being 107 ft., compared with 123 ft. 9½ in. for the S1. It was specified that the locomotives should be capable of hauling a train weighing 880 tons at a maximum speed of 100 miles an hour on a level track. The first of this class of engine is illustrated in Fig. 1, on this page. Another 50 have recently been built: 25 at Altoona, and 25 at the Baldwin Locomotive Works. The boiler is 8 ft. 4 in. in diameter at the largest course, adjacent to the firebox. The distance over the tube-plates is 18 ft., and there are 184 2½-in. smoke tubes and 69 5½-in. superheater flue tubes. The net gas area through the tubes is 10·6 sq. ft., and the grate area is 92 sq. ft. The working steam pressure is 300 lb. per square inch, and the firebox is provided with a combustion chamber, and five "circulator" tubes which support the brick-arch. The cross-sectional areas of the steam passage between the boiler and cylinders are 78·9 sq. in. for the steam pipe in the boiler; 137·6 sq. in. for the superheater elements; 101·7 sq. in. at the throttle valves; and 63·6 sq. in. at each steam pipe to the cylinders. Some additional dimensions and ratios of the boiler are given in Table I.

The main frame or bed of the locomotive is a single nickel-steel casting which incorporates the cylinders. The diameter of the coupled wheels is 6 ft. 8 in., and the four simple-expansion cylinders are 19¾ in. in diameter, with a piston stroke of 26 in. Each cylinder is fitted with eight poppet valves, four at each end, of which two, 5 in. in diameter, are for steam admission and two, 6 in. in diameter, are for exhaust. The weight of the reciprocating parts for one front cylinder is 1,041 lb., and for one rear cylinder, 951 lb. The maximum rated tractive effort is 65,000 lb. at 85 per cent. boiler pressure. The adhesive weight is 268,200 lb., the total weight of the locomotive is 497,200 lb., and the factor of adhesion is 4·13. The tender weighs 433,000 lb.; the total weight of engine and tender is therefore 415 tons.

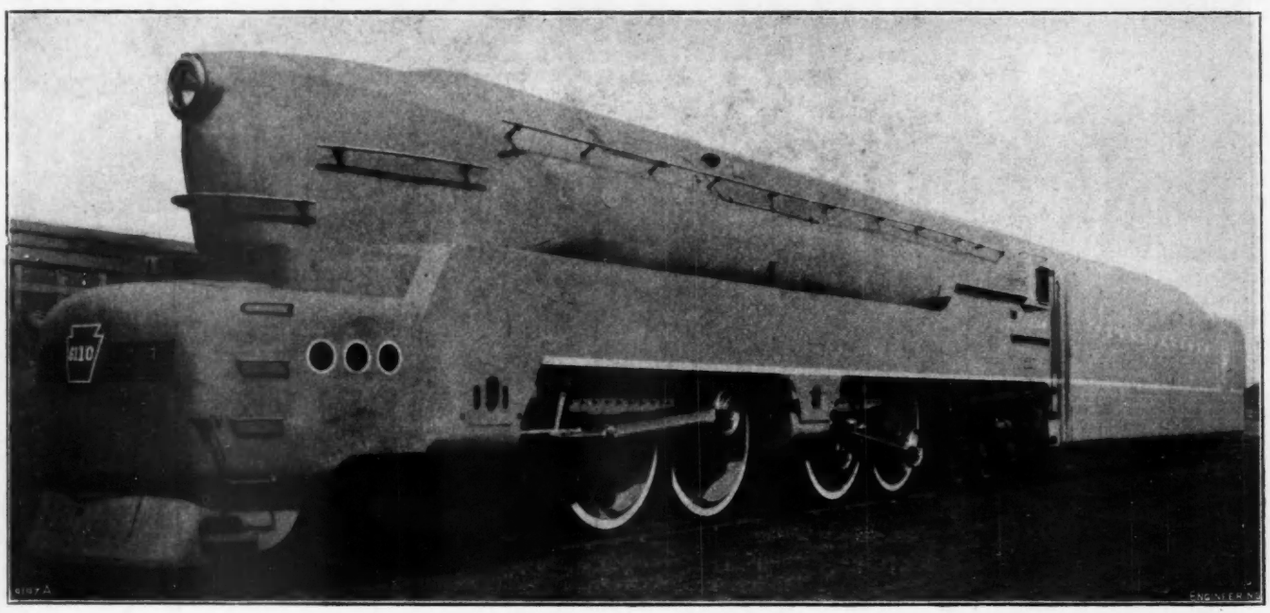


FIG. 1. CLASS T1 PASSENGER LOCOMOTIVE.

The first of these T1 locomotives, No. 6110, was delivered to the Pennsylvania Railroad in April, 1942, and the second, No. 6111, in May, 1942. Locomotive No. 6110 made its first through trip from Harrisburg, Pa., to Chicago, with a train of 14 coaches weighing 1,000 tons; and between Crestline, Ohio, and Chicago, a distance of 280 miles,

TABLE I.—*Boiler Heating Surfaces and Ratios.*

Heating Surface or Ratio	—
Heating surface:—	
Firebox and combustion chamber, sq. ft.	419
Circulators, sq. ft.	80
Firebox, total, sq. ft.	499
Tubes and flues, sq. ft.	3,719
Evaporative, total, sq. ft.	4,218
Superheater, sq. ft.	1,680
Combined total, sq. ft.	5,898
Firebox heating surface/Combined heating surface, per cent.	8·4
Superheater surface/Combined heating surface, per cent.	28·5
Firebox heating surface/Grate area	5·42
Firebox volume/Grate area	6·06
Tube and flue heating surface/Grate area	40·4
Superheater surface/Grate area	18·3
Evaporative heating surface/Grate area	45·8
Combined heating surface/Grate area	64·6
Gas area/Grate area, per cent.	11·4

TESTS OF PASSENGER LOCOMOTIVE; PENNSYLVANIA RAILROAD.

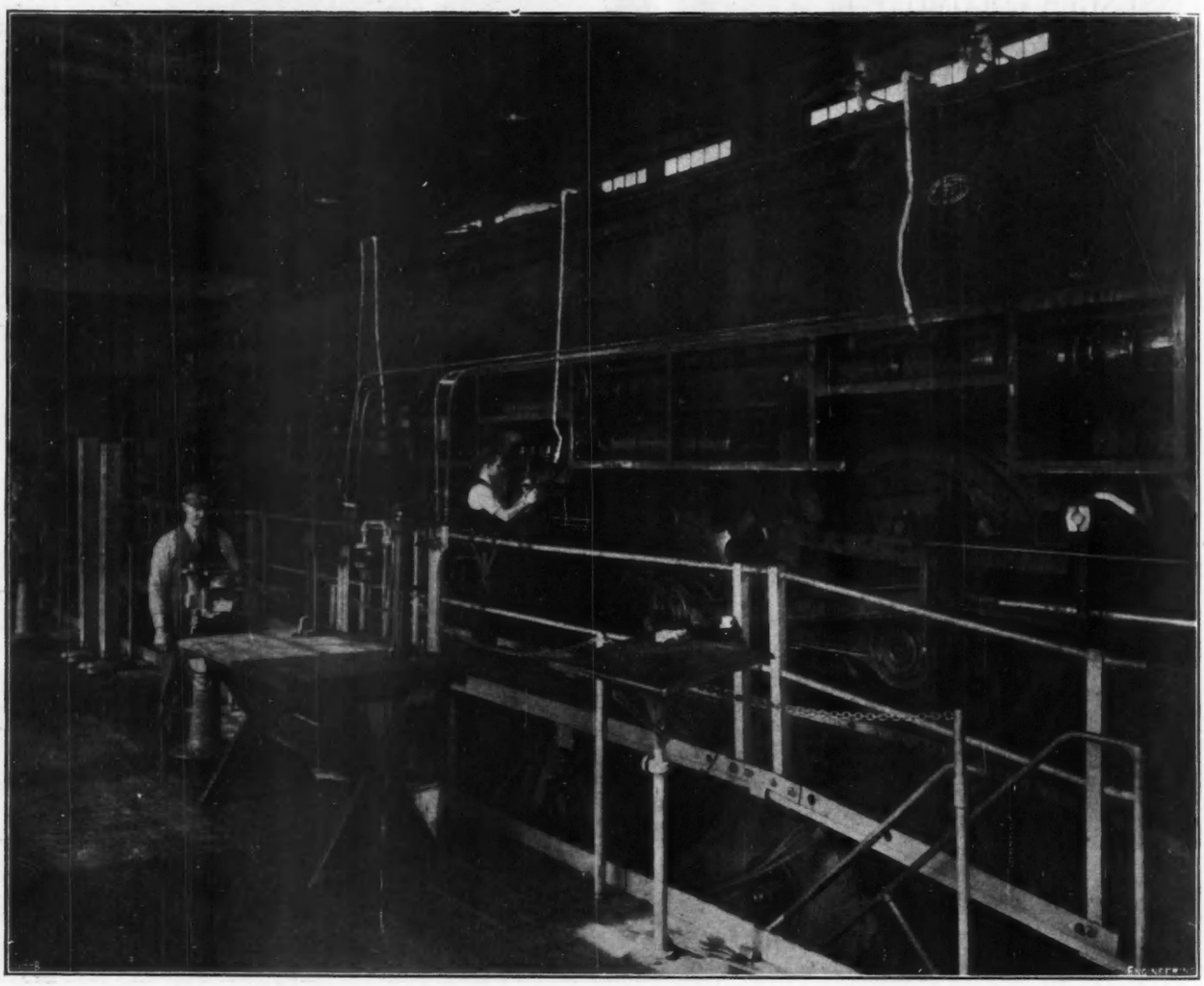


FIG. 2. LOCOMOTIVE UNDER TEST AT ALTOONA.

the speed is understood to have been consistently about 100 miles an hour. On another occasion, engine No. 6111, when hauling a train of 16 coaches, maintained an average speed of 102 miles an hour on the same section of the line for a distance of 69 miles. In April, 1944, engine No. 6110, after having run about 120,000 miles, was sent to the Locomotive Testing Plant at Altoona, Pa., for a complete series of trials. It is shown under test in Fig. 2, on this page. Up to that time, it was the most powerful passenger locomotive to have been tested on the plant, and the maximum power reached was 6,552 indicated horse-power. The conditions under which this very high power was attained were as follows: speed, 85·5 miles an hour; cut-off, 25 per cent.; boiler pressure, 295 lb. per square inch; steam-chest pressure, 287 lb. per square inch; steam temperature at steam-chest, 757 deg. F.; steam to cylinders, 101,219 lb. per hour; and steam per indicated horse-power per hour, 15·4 lb.

Tests were made at speeds of 38, 57, 67, 76, 85, 95 and 100 miles an hour, corresponding to 160, 240, 280, 320, 340, 400 and 420 r.p.m. of the driving wheels, at various cut-offs from 10 per cent. to 50 per cent. The coal used was highly volatile, with all slack under ¾-in. size screened out. The calorific value was 14,123 B.Th.U. per pound, and the ash content was 7·58 per cent.

The performance of the boiler and superheater is shown in Fig. 3, opposite, which has been prepared from a graph in Mr. Johnson's paper. The rates of firing range from 60 lb. to 240 lb. of dry coal per square foot of grate area per hour. The graph is based on the temperature of the feed water as delivered by the feed-water heater. It shows the heat balance, being sub-divided to give the loss in the smokebox gases, the firebox combustion efficiency (that is, the relation between the coal fired and burnt and that escaping unburnt), and the loss due to the formation of carbon monoxide. The small heat loss due to external radiation is also shown.

The smokebox gas temperatures ranged between the limits of 600 deg. and 807 deg. F., for firing rates from 60 lb. to 240 lb. of dry coal per square foot of grate area per hour. Further information relating to the boiler performance is given in Table II, on this page. The data refer to seven tests at high rates of power, from 4,838 to 6,666 indicated horse-power. The firing rates ranged from 150 lb. to 262 lb. of coal per square foot of grate area per hour, based on the coal as fired, and not on dry coal. The evaporative rates are from 80,620 lb. to 105,475 lb. of water an hour, corresponding to 20·41 lb. to 25·18 lb. of water per square foot of evaporative heating surface per hour. At all these high rates of evaporation the boiler pressure was constantly maintained within a few pounds of the working pressure of 300 lb. per square inch, and the throttle valves were fully

TABLE II.—BOILER PERFORMANCE: COAL FIRED AND WATER EVAPORATED.

No. of Test.	Speed.		Cut-off.	Total Weight f Coal, as Fired, per Hour.	Coal Fired per sq. ft. of Grate Area per Hour.	Total Water Evaporated per Hour.	Water Evaporated per lb. of Coal.	Water Evaporated per sq. ft. of Evaporative Heating Surface per Hour.	Boiler Steam Pressure.
	Miles an Hour.	R.p.m.	Per cent.	Lb.	Lb.	Lb.	Lb.	Lb.	Lb. per Sq. In.
1473 ..	38	160	50	13,703	150·1	80,620	5·86	20·41	296
1427 ..	57	240	40	19,340	211·8	96,574	4·98	22·93	297
1406 ..	67	280	30	16,970	185·9	94,236	5·54	22·40	293
1442 ..	76	320	35	22,620	247·8	101,583	4·48	24·20	294
1414 ..	86	360	25	18,370	201·2	102,816	5·59	24·43	295
1444 ..	95	400	20	19,536	214·0	97,949	4·99	23·22	295
1448 ..	100	420	20	24,000	262·9	105,475	4·37	25·18	296

TEST RESULTS, CLASS T1 LOCOMOTIVE.

Fig. 3.

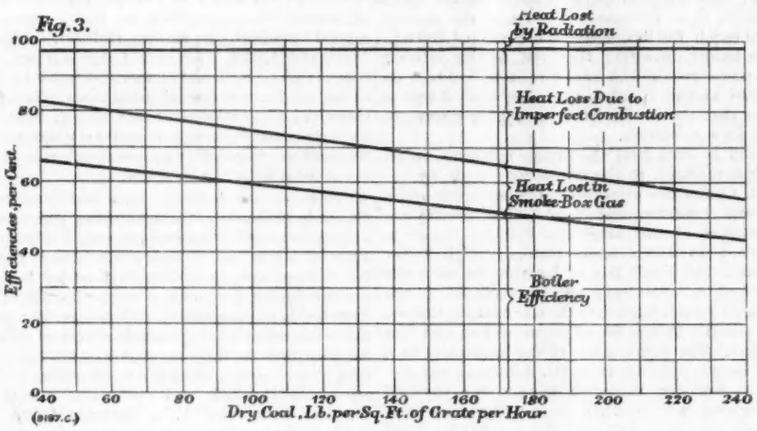


Fig. 4.

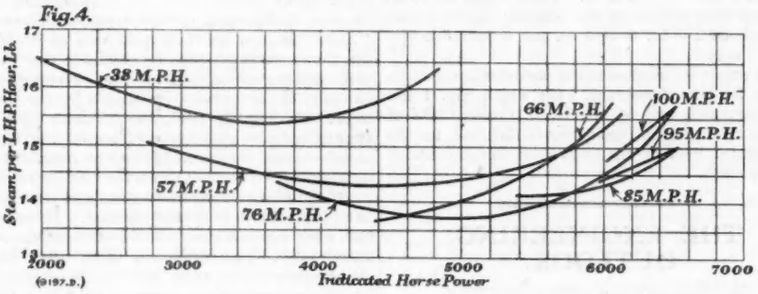
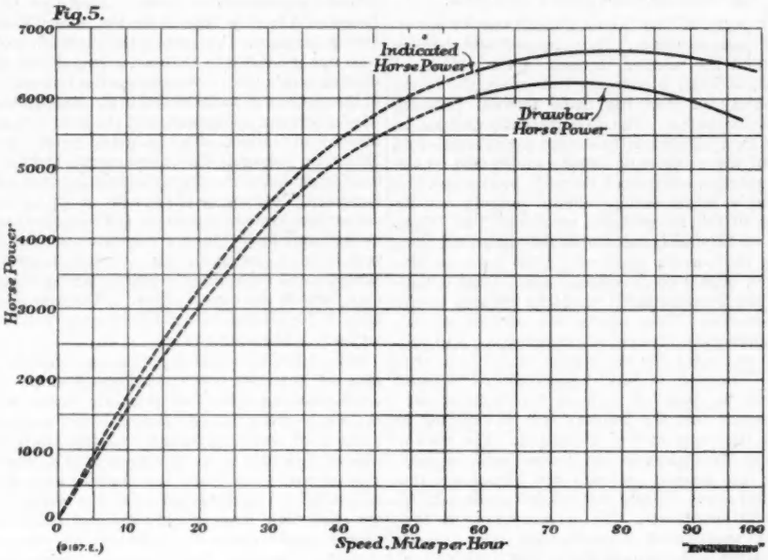


Fig. 5.



ordinary interest, on account of the steam-distribution system employed. The poppet valves are actuated by a valve mechanism which permits the independent operation of the inlet and exhaust valves, in such a manner that the rate of admission may be adjusted while maintaining a consistently late release point. Thus, with a valve gear of this description, the period of the expansion of the steam is increased by separating, as widely as possible, the points of cut-off and the points of exhaust-port opening.

The steam consumptions per indicated horse-power-hour, furnished by the test data, are the first known to the writer, to have been obtained on a locomotive testing plant with a steam-distributing system of this kind. An overall picture of the steam consumption at all rates of power is given by the group of curves in Fig. 4. The curves are plotted for each of the speeds at which the engine was tested, and show the steam rates, based on the weight of steam delivered by the superheater to the engines, against the indicated horse-power. The lowest steam rate shown is 13·6 lb. per indicated horse-power hour, obtained at 76 m.p.h., or 320 r.p.m., when the cut-off is stated to have been 20 per cent. At speeds from 57 m.p.h. upwards, and for power ranging from about 3,000 to 6,500 indicated horse-power, the steam required per indicated horse-power hour was between about 14 lb. and 15·5 lb.

A more detailed analysis of the cylinder performance is given in Table III, which covers certain high-power tests. This table corresponds to the same tests as those in Table II, and gives information respecting the performance of the boiler and superheater. Referring to the evaporative rates given in Table II, and the particulars of the weight of the superheated steam actually supplied to the engines, i.e., the cylinder feed, the difference between these amounts is the steam required by auxiliary equipment which, on the testing plant, consists only of that required to operate the stoker engine and the steam used by the stoker steam jets. As already mentioned, the steam used by the turbo-feed-heater is not included in the "total evaporation" figures, as it is returned to the boiler as part of the feed. At total evaporative rates above 75,000 lb. per hour, the heater uses about 5·5 per cent. of the total.

Columns (2) to (7) in Table III give particulars of the steam conditions in relation to the pressures and temperatures at which it was supplied to the cylinders, and the pressures in the exhaust passages. Test 1448 shows that the power developed was 6,666 indicated horse-power, but the maximum power is officially considered to be 6,552 indicated horse-power. The highest power actually indicated during this test, when plotted, lies off an average curve of power developed and it is therefore not regarded as the maximum power that can be obtained normally. The steam flow through the steam pipes and the superheater varies between 79,089 lb. and 103,826 lb. per hour, for pressure losses of only 4 lb. to 12 lb. per square inch. The exhaust-steam pressures range from 15·3 lb. to 25·9 lb. per square inch, for total evaporations from 80,620 lb. to 105,475 lb. of water per hour (Table II). While

TABLE III.—ENGINE PERFORMANCE.

No. of Test.	Steam Pressures, Lb. per Sq. in.				Temperature of Steam in Steam Pipes, Deg. F.	Deg. F. of Superheat.	Weight of Steam to Cylinders, Lb. per Hour.	Indicated Horse-power.	Weight of Steam per I.h.p.-hr., lb.	Total Heat of Superheated Steam above 32 deg. F., B.Th.U. per Lb.	Heat Used in Cylinders, B.Th.U. per lb. of Steam.	Efficiency of Cylinders, per cent. Col. (12) / Col. (11) × 100	Heat Available per Lb. of Steam above Exhaust at 15 lb. per Sq. in., B.Th.U.	Efficiency of Cylinders, per cent. Col. (12) / Col. (14) × 100
	Boiler.	Steam Pipes.	Pressure Drop.	Exhaust Passage.										
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
1473	296	292	4	18·1	741	322	79,089	4,838	16·3	1,389	156·1	11·25	283	55·0
1427	297	292	5	19·3	738	319	94,954	6,105	15·6	1,388	163·0	11·72	282	57·8
1406	293	281	12	15·3	738	320	92,667	6,021	15·4	1,388	165·2	12·00	279	59·2
1442	294	286	8	29·4	799	381	99,321	6,484	15·3	1,420	166·0	11·68	214	54·0
1414	295	287	8	24·2	757	339	101,219	6,552	15·4	1,398	164·0	11·79	284	58·0
1444	295	288	7	25·0	781	363	96,300	5,544	14·6	1,411	173·0	12·29	291	59·4
1448	296	288	8	25·9	728	310	103,826	6,666	15·5	1,383	163·1	11·76	278	57·6

open. The evaporative rates given are the totals based on the total amount of water delivered to the boiler, made up of that supplied to the engines and the auxiliaries, but excluding the steam used by the turbine-driven feed-water heater, the exhaust from which is condensed in the feed-heater and returned with the hot feed to the boiler.

Apart from the high powers developed by this remarkable locomotive, the cylinder performance as determined on the test plant is of more than these exhaust pressures detract from the mean effective pressures, they are relatively low, when related to the high evaporative rates obtained, and indicate a free-steaming boiler and efficient draughting at the front end. A further point of note is

seen in the steam temperatures, which may be considered high. They range from 741 to 799 deg. F., for steam flows from 79,089 lb. to 99,321 lb. per hour. At higher rates of working, the steam temperatures show a tendency to fall, probably due to the firebox reaching the limit of its capacity to burn the coal fired, and possibly due to some "carry over" at very high rates of evaporation. The high degree of superheat shown is reflected in the comparatively low steam consumptions per indicated horse-power hour at cut-offs as long as 30 and 35 per cent. At 400 r.p.m. (95 m.p.h.) and 20 per cent. cut-off, the steam rate is 14·6 lb. per indicated horse-power hour, based on the actual cylinder feed.

Columns (11) to (15) in Table III show the efficiency of utilisation of the steam in the cylinders from two points of view. The values given in Column (12), for the heat used in the cylinders per pound of steam, are obtained by expressing the indicated horse-power, Column (9), in equivalent B.Th.U. per hour (2,545 B.Th.U. = 1 horse-power hour), and dividing the result by the weight of steam supplied to the cylinders per hour (Column (8)). The efficiency of the cylinders, based on the total heat in the superheated steam supplied to the cylinders (above 32 deg. F.), is then obtained, and is shown in Column (13). The efficiency of the cylinders, however, may be regarded from another point of view. Test Plant Bulletin No. 21, *Tests of a Class E.65 Passenger Locomotive*, published by the Pennsylvania Railroad, suggests that it is impossible for a locomotive to have less waste heat in the exhaust than 1,000 B.Th.U. per pound of steam above 32 deg. F. feed water. From this, it is argued that, if the steam has a heat value of, say, 1,199·6 B.Th.U. per pound, then only 199·6 B.Th.U. can be used, *i.e.*, 16·6 per cent. of the total. Test Plant Bulletin No. 18, *Tests of a Class K.2sa Locomotive*, also refers to this by stating that, in considering the performance of a non-condensing engine, and especially when comparing one engine with another, any diagram showing steam consumption should have the B.Th.U. calculated from a standard feed temperature, and not from the actual temperature of the feed water, if it is not the same in each case. Thus, it is considered desirable to base the efficiency of the cylinders on the heat available in the steam in excess of 1,000 B.Th.U. The author prefers to base the efficiency of the cylinders on the theoretical heat drop between the total heat of the superheated steam and the total heat of the exhaust steam at 15 lb. per square inch absolute. Efficiencies calculated on this basis are shown in Column (15). It will be noted that, at 400 r.p.m. and 20 per cent. cut-off, the efficiency is almost 60 per cent.

The curves in Fig. 5, on page 195, show the power developed in the cylinders and at the drawbar, corrected for a water rate of 100,000 lb. per hour. The parts of the curves indicated by broken lines are empirical, because the cylinders would not use a steam supply of 100,000 lb. per hour at speeds below about 60 miles an hour. The relative positions of these two curves indicate that losses due to machine friction are particularly small. The mechanical efficiency ranged from about 90 per cent. at high speeds, to 97 per cent. at 38 m.p.h. In considering this high mechanical efficiency, it must be remembered that the drawbar horse-power obtained on the locomotive testing plant is higher that would be developed on the track, as the resistance to traction is made up of only the frictional resistance of the machinery. Furthermore, this engine is not only completely equipped with roller-bearing axleboxes and roller-bearings on the connecting-rod and coupling-rod crankpins and crosshead pins, but is also fitted with poppet valves and special valve gear which undoubtedly have a much lower frictional resistance than piston valves and conventional valve-gear. From the point of view of power output, the performance of this engine is outstanding, especially when it is realised that the high power of 6,552 indicated horse-power was developed at a speed of 360 r.p.m. at a short cut-off of 25 per cent., under which conditions 101,219 lb. of steam were passed through the four relatively small cylinders per hour. Each cylinder used 25,305 lb. of steam per hour, and developed 1,638 indicated horse-power.

At very high speeds the T1 locomotive can develop almost maximum power at 15 per cent. cut-off, and to produce less power under these conditions it is necessary to throttle the engine. At 100 m.p.h. the locomotive can develop 4,100 h.p. at the tender drawbar; therefore, as the drawbar horse-power required to haul a train of 880 tons on the level at this speed is not more than 2,980, it follows that the engine has a very high reserve of power for acceleration.

It will be seen that the design conforms, in its principal features, to the suggestions made by the A.A.R. Committee responsible for the trials made with the 1,000-ton test train. The remarkable performance of this large four-cylinder engine is attributed to three main factors: high boiler pressure; the small loss of pressure between the boiler and the cylinders; and the large size of the admission valves, relative to the size of the cylinders, made possible by the use of poppet-valves and four cylinders. The performance of the locomotive as a whole shows—quoting from Mr. Johnson's paper—that, at low and moderate powers, the dry-coal consumption per drawbar horse-power hour was generally less than 2·5 lb. From 5,500 to 6,000 drawbar horse-power the coal consumption increased from about 2·5 lb. to 3·5 lb. per drawbar horse-power hour.

The writer is indebted to the Baldwin Locomotive Works for the photograph from which Fig. 1 has been prepared, and to Mr. H. T. Cover, Chief of Motive Power of the Pennsylvania Railroad, for the photograph showing the engine on the locomotive testing plant.

THE ENGINEERING OUTLOOK.

IX.—The Motor-Vehicle Industry.

The year 1947 has been a difficult one for motor-vehicle manufacturers. The continued steel shortage prevented the planned increase in the volume of output, and the uncertainty concerning the future availability of steel has made forward planning almost impossible. The Government's decision to relate steel allocations to export performance and to limit the numbers of motor vehicles sold on the home market, interpreted literally, means that the industry's future hangs almost entirely on its ability to sell its products overseas. The White Paper on *Capital Investment in* 1948 indicated that, during the current year, only 6,000 public-service vehicles, 50,000 goods vehicles and 50,000 private cars "for business use" would be released to the home market. These figures were arrived at after an examination of essential requirements, and provision was made for the release of a "somewhat higher" number of cars, "since not all essential cars can be classified as being for business use." This means that the industry will be expected to export the remainder of its output. The Society of Motor Manufacturers and Traders estimate that, taking into account probable steel allocations, this will total about 250,000 cars, 85,000 goods vehicles and 6,000 omnibuses. The magnitude of this task can be appreciated by comparing these targets with export achievements during 1947, which were a record for the industry. Exports of cars totalled less than 150,000, of goods vehicles slightly less than 50,000, and of passenger vehicles about 3,500. Some doubts have been expressed concerning the industry's ability to reach these targets, particularly in view of the fact that, during 1947, many overseas markets became closed to British cars through Governmental decisions to ban imports, and others restricted by strict licencing of all imports. Moreover, in those markets remaining open there were indications, during the latter part of the year, that the sellers' market was coming to an end. The result of the International Trade Conference at Geneva, where the British Government failed to obtain the adoption of a tariff based on weight and had to make partial surrenders of Empire preferences, was a bitter blow to British motor manufacturers, and cannot fail to have an adverse effect on their export sales.

In recent months, however, there have been hopeful signs of improvements in the general situation. The abandonment of the convertibility of sterling, the growing world dollar shortage, and the successful conclusion of certain bilateral trading agreements have resulted in the re-opening of several markets, including Holland, Argentina, India and Egypt. The world shortage and rising cost of fuel oil is another important factor in favour of increased export sales of British cars. On balance, therefore, the outlook for the British industry is not unfavourable, though it remains uncertain. An essential pre-requisite to success in achieving targets is a general reduction in prices.

Critics of the industry have loudly advocated sweeping changes in manufacturing policy, on the assumption that a lowering of prices could not be effected otherwise Among the varied proposals put forward were the reduction of models to one per manufacturing firm, and a large measure of standardisation of components and accessories; pooling the resources of leading manufacturers to produce a car designed for export markets—on the ground that "only such grouping would suffice to secure economies through mass-production methods as practised in the U.S.A."; the manufacture of a small cheap car for the home market, such as the German *Volkswagen*, on the same co-operative or "State" lines as for the export car; and action by the Government to curb or eliminate the "monopolies and cartels" alleged to exist. To some extent, the fears of the critics were shared by the Government. In August, 1947, the Minister of Supply approached the industry and stated the Government's views that manufacturers must intensify standardisation and cut down the number of models in order to lower production costs and thus become more competitive in export markets. He suggested that each manufacturer should concentrate on one model only. This approach came after lengthy deliberations between the Government, industry and labour representatives during meetings of the National Advisory Council for the Motor Manufacturing Industry. A report on the Council's proceedings was published in October, giving details of the Government's policy concerning the industry, and of the progress so far achieved in the standardisation of components, equipment, and the reduction of the number of models. The industry replied to the Minister's proposals within one month, and in September published its reply, emphasising that manufacturers "fully realise the gravity of the times and are anxious to co-operate to the full with the Government," and that "they are wishful to play their part both in closing the gap between imports and exports and in checking the inflationary spiral which may imperil the export effort." The report gives details of what has been achieved and what further action it is proposed to take.

Since 1939, the number of basic models has been reduced from 136 to 62; and programmes which will be completed in 12 to 18 months further reduce the number to 42, a reduction of 70 per cent. The number of body variations will then have been reduced from 299 to 40—a reduction of 87 per cent. This by no means meets the Minister's request for one model per manufacturer, but the report points out that "any more quickly enforced reduction of models would throw the industry into chaos, for arbitrary changes would seriously affect costs, involving much loss of special tools, machinery and materials in progress." It is also stated that, in the view of manufacturers, the export markets require variety and quality owing to different physical conditions all over the world, different demands and foreign competition, and that "any suddenly enforced reduction of models would make the attainment of the export targets impossible." The industry's reluctance to adopt a radical policy of model reduction and standardisation is doubtless rightly influenced by considerations of inevitable disruptions in manufacturing programmes and of tooling losses, but it is also plain that the roots are much deeper. Hitherto, competition has been mainly for a limited home market, heavily protected by a 33⅓ per cent. import duty, and by a taxation system which favoured cars of low horse-power. The capacity of the industry has always exceeded by a substantial margin the demand for its products. This demand has been conditioned, more than that of any other engineering industry, by the high cost

of motoring in Britain. Another factor of considerable importance has been the long life of British cars and the consequent heavy trade in second-hand cars.

Manufacturers, therefore, attempted to increase new car sales by frequent model changes. The success of any large manufacturer depended on his ability to cater for every section of the motoring public and for the varying tastes in each section; hence the multiplicity of models. The one-model policy—such as that of Ford with his "Model T"—long abandoned by the Ford Motor Company in the United States, was never adopted in Britain, though the importance of a large volume led manufacturers to compete for the market for low-priced cars of low running cost, cutting down profits on new car sales, and recouping themselves by sales of spare parts and components.

The problems outlined above were extremely complex, and the manner in which manufacturers attempted to solve them largely determined the structural growth of the industry. As stated in the industry's report to the Minister of Supply: "No motor-car manufacturer has at any time made a variety of models just for the sake of making them. He has been constrained to adopt this course by the economics of the market, by the type of plant available, and—particularly in the United Kingdom—by the high and graduated rate of tax, leading to demands from customers for the cars the taxation costs of which they felt they could afford." More than the horse-power tax—which, admittedly, had an important psychological value—the weight of taxation helped, as a major constituent in the high costs of motoring, to limit the home market to some two million cars. The probability that pre-war problems will recur must play a major part in manufacturers' day-to-day decisions, and goes far to explain their resistance to some of the radical changes advocated by the industry's critics.

Manufacturers' comments on standardisation of components and car equipment betray the same underlying fear as their comments on reduction of models—that, carried too far, it will prejudice and, to a large extent, destroy the competitive character of the industry. While admitting that the standardisation of some parts of components can be achieved, the report emphasises that "complete standardisation must stultify all progress."

The factors outlined above explain the manufacturers' reluctance to fall in line with their critics, but this does not solve the urgent need of reducing costs and increasing exports. Prices have increased steadily throughout 1947. The only British makes selling at the same price in January, 1948, as in January, 1947, were Ford, Vauxhall, Morris and Wolseley. Increases range from 3½ per cent. in the price of a Standard 8-h.p. to 17 per cent. in the price of a Rover 10-h.p. (no longer made). A comparison, in August, 1947, of retail prices of selected British and American cars in Sydney, Australia, shows that the cheapest British cars—the Ford 10 h.p., Vauxhall 12 h.p., Hillman 10 h.p. and Austin 10 h.p., ranged from 517*l.* to 631*l.*, whereas the prices of American standard models—Chevrolet, Fleetmaster, Ford Super de luxe and Plymouth Special de luxe, ranged from 730*l.* to 797*l.* The price advantage of "volume-produced" British cars could be reduced considerably by any alteration in tariff policy. Already the better-quality British cars, such as the Daimler 2½-litre, were twice as expensive as the best Buicks, and the Bentley MK.4 more than 3½ times dearer than the Packard Clipper "6." The explanation of the high British costs is undoubtedly found in the small volume of production of any one model. This, in turn, is partly due to the diversity of models, but mainly to the fact that no British manufacturer can hope to achieve the volume production of any one model of the American Ford, Chevrolet or Plymouth. There is a large measure of agreement to the effect that the British industry cannot compete on price with the American industry.

The present situation regarding costs is most alarming. The Government's steel allocations to the industry will allow the production of about 350,000 cars during 1948; but this figure does not represent the full capacity of the industry even before the war, when considerable seasonal fluctuations in demand forced manufacturers to maintain plant and equipment corresponding to their requirements during periods of peak demand. It is probable that, with available equipment, the industry could have produced 600,000 cars a year had the demand not fluctuated. One leading manufacturer stated that an even flow of work throughout the year would have resulted in a 50 per cent. decrease in labour costs and a 50 per cent. increase in the volume of output. Any reduction in the volume of output must increase costs, and therefore it is of primary importance to the industry, in its efforts to compete overseas, that enough materials should be made available to permit full-capacity production. The position is summarised in the report already quoted: "The costs, and hence the prices of motor cars, depend on the prices of basic materials and on volume of production. The prices of basic materials are out of the hands of the industry and recently announced increases give rise to apprehension. The increase in volume of production was halted a year ago and the industry has not yet fully attained its pre-war volume. Every firm is greatly below capacity and a bold policy of increase in production is required to overcome that situation and so contribute to the holding down of costs."

This states the real problem of the industry—the limited quantity of steel available is inadequate for full-capacity production. Steel was initially allocated by the Ministry of Supply to individual firms on a reasonably equitable basis. Towards the end of last year, allocations began to be made in accordance with export performance, and when Sir Stafford Cripps announced that steel would only be allocated to firms able to reach their export targets it became clear that the whole future of the industry was at stake. At present it cannot produce at the lowest possible cost owing to material restrictions. During 1947, substantial inroads had to be made in steel stocks. Any firm failing to export will find its already insufficient steel allocation cut down; its costs will rise in consequence and its ability to export will be further impaired. With the high export targets determined by the Government's ceiling on releases to the home market, it is almost inevitable that steel allocations will fall during the present year. If this fall is not arrested, the industry may

TABLE I.—*United Kingdom Production of Motor Vehicles.*

(Monthly Averages or Calendar Months.)

Year.	Passenger Cars.		Commercial Vehicles.		Public-Service Vehicles.	
	Total.	For Export.	Total.	For Export.	Total.	For Export.
1938 ..	28,532	—	8,667	1,189	•	•
1944 ..	175	—	10,904	—	•	•
1945 ..	1,411	—	10,206	—	•	•
1946 ..	18,264	8,298	10,914	3,752	802	266
1947 ..	23,917	12,914	11,796	3,857	1,061	343
Jan. ..	25,005	11,475	12,145	3,747	958	321
Feb. ..	9,921	4,600	5,224	1,396	509	114
Mar. ..	22,074	9,999	10,449	3,203	831	223
April ..	24,230	11,364	11,355	3,416	920	303
May ..	27,496	13,163	13,308	4,047	941	528
June ..	29,268	13,750	12,201	4,048	1,559	509
July ..	24,903	12,557	10,893	3,336	1,051	299
Aug. ..	20,854	11,493	9,832	3,043	885	311
Sept. ..	28,444	18,376	15,330	5,301	1,319	388
Oct. ..	26,236	17,564	13,000	5,340	1,091	349
Nov. ..	23,576	15,399	12,497	4,671	1,237	431
Dec. ..	24,993	15,226	14,313	5,407	1,436	539

• Included in "Commercial Vehicles."

TABLE II.—*Production of Passenger Cars* by Main Horse-Power Classes.* (Numbers.)

(Monthly Averages or Calendar Months.)

Year.	Not exceeding 8 h.p.	8 h.p. to 12 h.p.	12 h.p. to 16 h.p.	16 h.p. to 20 h.p.	Over 20 h.p.	Total.
1938 ..	—	—	—	—	—	—
1944 ..	—	26	—	—	—	26
1945 ..	414	627	16	6	6	1,069
1946 ..	6,734	8,736	2,300	242	190	18,202
1947 ..	7,398	11,695	4,140	243	434	23,910
Jan. ..	8,147	12,385	3,819	272	372	24,995
Feb. ..	3,173	4,768	1,617	168	191	9,917
Mar. ..	7,115	10,842	3,640	178	291	22,066
April ..	7,536	9,425	3,955	227	379	21,522
May ..	8,849	13,643	4,214	317	465	27,488
June ..	9,424	14,120	5,014	265	435	29,258
July ..	8,446	11,929	3,791	318	414	24,898
Aug. ..	6,437	10,520	3,453	161	282	20,853
Sept. ..	8,472	13,686	5,159	327	797	28,441
Oct. ..	8,037	12,723	4,863	205	399	26,227
Nov. ..	6,682	11,437	4,727	222	508	23,576
Dec. ..	6,457	12,163	5,427	254	672	24,973

* Including chassis delivered as such by motor manufacturers.

TABLE III.—*Production of Commercial Motor Vehicles by Main Classes.* (Numbers.)

(Monthly Average or Calendar Months.)

Year.	Under 15 cwt.	15 cwt. and under 6 tons.	6 tons and over.	Total.
1938	—	—	—	—
1944	573	1,169	73	1,815
1945	1,242	3,155	110	4,507
1946	4,016	6,620	281	10,917
1947	4,820	6,642	334	11,796
Jan.	4,807	7,083	255	12,145
Feb. ..	1,975	3,033	216	5,224
March ..	4,186	5,998	265	10,449
April ..	4,740	6,377	238	11,355
May	5,792	7,155	361	13,308
June	5,272	7,540	389	13,201
July ..	4,596	6,048	249	10,893
Aug. ..	3,869	5,606	357	9,832
Sept. ..	6,545	8,323	462	15,330
Oct.	5,614	7,033	353	13,000
Nov.	5,422	6,677	398	12,497
Dec. ..	5,020	8,830	463	14,313

TABLE IV.—*United Kingdom Exports of Private Cars.* (Numbers.)

Year.	Completed Cars.		Chassis.	Engines.	Total Value, including Parts.* (£1,000.)
	New.	Second-Hand.			
1938 ..	44,123	7,124†	26,301	7,750‡	10,993
1939 ..	43,230	4,852	23,803	9,062	10,300
1940 ..	20,654	1,650	107,055	7,342	6,150
1941 ..	3,831	351	655	2,044	2,307
1942 ..	58	77	14	1,252	1,375
1943 ..	1,033	133	3	1,328	1,514
1944 ..	37	150	38	355	1,952
1945 ..	1,952	5,218†	1,175	2,328‡	4,069
1946 ..	69,806	1,696	16,810	12,277‡	26,660
1947 ..	125,788	557	17,300	20,971‡	48,528

* Includes parts for commercial and passenger-service vehicles.
† Includes second-hand commercial vehicles.
‡ Includes engines for commercial vehicles.

TABLE V.—*United Kingdom Exports of Commercial Vehicles.* (Numbers.)

Year.	Commercial Vehicles.		Chassis.	Engines.	Total Value, (£1,000.)
	New.	Second-hand.			
1938 ..	3,384	—	10,889	—	3,883
1939 ..	2,278	90	9,095	268	2,783
1940 ..	3,939	20	5,163	386	2,206
1941 ..	2,018	20	369	130	1,288
1942 ..	3,298	28	33	120	2,237
1943 ..	3,311	69	35	93	2,728
1944 ..	4,548	96	197	109	2,817
1945 ..	5,464	—	1,051	—	2,498
1946 ..	24,731	8,705	22,983	—	21,520
1947 ..	23,733	5,951	25,622	—	25,416

TABLE VI.—*United Kingdom Exports of Motor Vehicles and Chassis by Main Countries of Destination*, 1947.

——	£1,000.	Per cent.
British Countries :—		
Union of South Africa	4,787	7·9
Australia	4,663	7·7
British India	4,042	6·6
New Zealand	3,994	6·5
Eire	2,928	4·8
British Malaya	1,633	2·7
Canada	476	0·8
Other British Countries ..	10,041	16·5
Total British Countries ..	32,564	53·5
Foreign Countries :—		
Belgium	4,224	6·9
Netherlands	3,884	6·3
Switzerland	2,140	3·5
Argentine	2,059	3·4
Portugal	1,933	3·2
Sweden	1,848	3·0
U.S.A.	335	0·6
Other American countries ..	772	1·3
Other Foreign countries	11,127	18·3
Total Foreign Countries ..	28,322	46·5
Total of above	60,886•	100·0
Total exports	74,967	—

• This total does not include exports of tractors, second-hand vehicles, parts and motor-vehicle equipment not specified by country of destination in *Trade and Navigation Returns*. The amount specified for each country may be incomplete in certain cases, because exports of certain items were too small to specify by country, and therefore were included under the headings "Other Countries."

gradually become bankrupt and disintegrate. The consequences of such a course of events are likely to be so wide and far-reaching throughout engineering that the Government would do well to re-examine their policy, and carefully to review all possible effects of the decision to relate steel allocations to export performance. The steps now taken to cope with a grave emergency must not destroy, without possibility of repair, the means of initiative and progress in an industry which before the war gave employment, directly and indirectly, to more than two million people.

The apprehension of manufacturers is illustrated by the following statements. Addressing the annual general meeting of the Austin Motor Company on November 26, 1947, Mr. L. P. Lord said: "Production for the last six months has been running at the rate of 1,950 to 2,050 vehicles a week, but I am sorry to say that during that time no increase in rate has been possible owing to shortages of supplies of all kinds. The present capacity of your factory is 3,400 vehicles per week, working two shifts. If the Government carry out their promise to give priority in supplies to the motor industry and to allocate materials to individual firms on the basis of past space, and causing labour to redistribute itself in other industries. Such an emergency measure should not be considered except in the gravest national emergency, such as a war, but it is possible that the gravity of the present crisis may impose such a course.

Production statistics are given in Tables I, II and III, on page 197, all being taken from the *Monthly Digest of Statistics*, January, 1948. Table I shows the average monthly production. During 1947, the industry produced 287,000 cars, 131,000 goods vehicles and 12,700 public-service vehicles. The adverse effect of the fuel crisis caused the February figures to drop from 50 to 60 per cent. Vehicles for export accounted for roughly half the car production and one third of the commercial and public-service vehicle production. The total value of deliveries during the period October, 1946, to September, 1947, was 175·3*l.* million, of which private cars and taxis accounted for 91·8*l.* million (52·3 per cent.), light and medium commercial vehicles 49·7*l.* million (28·4 per cent.), and heavy commercial vehicles and public-service vehicles 33·9*l.* million (19·3 per cent.). The 52 per cent. accounted for by private cars and taxis compares with 69 per

the war was in March of last year, when the number employed was 552,000 and 56,700 were unemployed due to the fuel crisis. It is difficult to estimate the number directly employed by the motor industry, owing to the reliance placed on general engineering firms for material and component supplies of all kinds. It is clear, however, that the labour on the books of manufacturers is considerably underemployed, owing to the difficulties of securing an even flow of supplies. If the Government could state the amounts of steel to be allocated during, say, the next three years, it is probable that motor manufacturers would adjust their labour strength accordingly; at present, uncertainty results in a considerable wastage of man-power. On the whole, labour relations have been satisfactory during the past year; one of the few strikes recorded was at the Rover factory, where 1,200 employees ceased work, claiming that trainees were being retained while skilled workers were made redundant. This type of strike may well typify labour relations during 1948, unless more steel is allocated.

The material position has been to the fore during 1947 probably more than any other aspect of the situation. One feature of steel shortage, however,

TABLE VII.—INTERNATIONAL EXPORTS OF MOTOR VEHICLES.

	1938.	Per cent.	1939.	Per cent.	1940.	Per cent.	1941.	Per cent.	1942.	Per cent.	1943.	Per cent.	1944.	Per cent.	1945.	Per cent.	1946.	Per cent.
PRIVATE CARS, COMPLETE (*Numbers*).																		
United Kingdom	44,123	14·5	43,230	17·9	20,654	16·2	3,831	4·5	58	0·4	1,033	17·1	37	1·0	1,952	55·6	71,502	36·8
Germany	60,099	19·8	60,728	25·2	13,297	10·5	—	—	—	—	—	—	—	—	—	—	—	—
France	19,302	6·4	509	0·2	4,234	3·2	657	0·8	334	2·3	2,964	48·7	1,798	51·5	351	10·1	2,299	1·1
Italy	18,486	6·1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3,668	1·9
United States	161,612	53·2	137,866	56·7	88,806	70·1	81,746	94·7	15,717	97·3	2,092	34·2	1,654	47·5	1,206	34·3	117,000	60·2
Total	303,622	100	242,333	100	126,991	100	86,234	100	16,109	100	6,089	100	3,489	100	3,509	180	194,469	100
COMMERCIAL VEHICLES (*Numbers*)																		
United Kingdom	14,273	7·4	11,373	8·0	9,101	7·3	2,387	1·6	3,331	1·6	3,346	3·5	4,745	2·6	6,515	4·1	56,419	23·5
Germany	12,617	6·5	14,570	10·4	11,848	9·5	—	—	—	—	—	—	—	—	—	—	—	—
France	2,396	1·3	618	0·4	494	0·2	431	0·3	8,375	5·0	9,010	10·4	3,547	1·9	617	0·7	12,345	5·1
Italy	18,486	9·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	332	0·1
United States	145,597	75·3	114,665	81·2	103,713	83·0	147,277	98·1	164,422	93·4	77,048	86·1	177,026	95·5	143,853	95·2	170,976	71·3
Total	193,369	100	141,226	100	125,156	100	150,095	100	176,128	100	89,404	100	185,318	100	150,985	100	240,072	100
MOTOR VEHICLES, PARTS AND ACCESSORIES (*Value*, £1,000).																		
United Kingdom	15,051	11·7	13,396	10·8	8,679	7·3	3,731	3·9	1,221	1·0	1,328	1·5	2,907	1·8	6,151	4·2	48,861	26·8
Germany	10,982	8·5	13,059	10·5	9,531	8·0	10,635	11·0	7,763	6·4	11,193	13·2	—	—	—	—	—	—
France	5,274	4·1	5,865	4·7	1,377	1·2	1,618	1·7	7,778	6·4	7,756	9·1	4,228	2·6	1,511	1·0	10,872	6·0
Italy	6,855	5·3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	487	0·2
United States	90,737	70·4	92,076	74·0	99,452	83·5	80,617	83·4	103,727	86·2	64,665	76·2	152,928	95·6	138,014	94·8	121,786	67·0
Total	128,899	100	124,396	100	119,039	100	96,601	100	120,489	100	84,942	100	160,063	100	145,676	100	182,006	100

performance, this output should be reached in a few months. If they do not, invaluable export markets which may remain open to us for no longer than the next nine to twelve months may be closed, or partly closed, and a great opportunity will be lost."

Sir William Rootes, at the meeting of Humber, Limited, on December 19, 1947, said: "Members are aware of the large amount of rehabilitation, modernisation, conversion and expansion which has been undertaken within our plants, carrying with it the further rationalisation of our manufacturing processes. This work is still in hand, and it is not anticipated that it will be finalised until the end of 1948 . . . Naturally, with the programme of expansion such as we have set ourselves, our position is bound to be somewhat difficult until circumstances allow us to produce to the full and take advantage of the resources we have created." The same points emerge from many other speeches made towards the end of last year.

It is clear that the pre-requisite to a lowering of production costs is full-capacity production, wherever possible on two-shift working; without this, no amount of standardisation and reduction of models will succeed. It is most unlikely, however, that enough steel can be made available, with the best will in the world. The industry could probably produce 800,000 cars a year, granted enough steel and components, without any substantial additions to its labour force. This would require some 800,000 tons of steel, of which about half would have to be sheet. This being out of the question for several years, there are two alternatives. The first is to let things alone, attempting cost reductions by the gradual increase of standardisation and relating allocations to export performance, in the hope that such an incentive will secure export sales. The second is for the industry to concentrate its output in the best-equipped plants, working to full capacity on a double-shift system, closing down redundant

cent. in 1935. No comparable figures exist for the trend of commercial and public-service vehicle manufacture towards a larger proportion either of light to medium vehicles (5 tons unladen weight or less) or of heavy vehicles. The importance by value of heavy-vehicle output, accounting for over 19 per cent. of total deliveries, is far greater than the numbers would indicate (about 10 per cent. in 1947). Light to medium commercial vehicles are produced mainly by "car" manufacturers. The latter accounted for some 80 per cent. of the total value of deliveries of the whole industry, more than nine tenths coming from the six leading car firms, namely, Austin, Ford, Nuffield, Rootes, Vauxhall and Standard. In addition, Vauxhall, Daimler and Rootes produced substantial quantities of omnibuses, the value being included under "heavy vehicles."

Table II shows the production of cars by main horse-power groups. It will be seen that nearly 80 per cent. of total deliveries during 1947 were of cars of 12 h.p. or below, compared with 77 per cent. in 1935. New models, such as the Standard Vanguard, the Austin A40, the Jowett Javelin, all of 14 to 16 h.p., were not yet in production, and it is expected that during 1948 the percentage of cars of medium horse-power will be substantially increased. Table III sets out the production of commercial vehicles, excluding omnibuses and trolley 'buses, in three main categories. The medium category, unfortunately, is too broad to permit any conclusion concerning the production by "heavy-vehicle" manufacturers, who build substantial numbers of vehicles between 5 tons and 6 tons, as the value figures discussed above indicate.

Little has been said so far concerning the labour position of the industry. The situation is still confused. At November, 1947, 554,200 were employed by the motor-vehicle, cycles and aircraft industries; this compares with 552,400 at June, 1946. The lowest employment figure recorded since

has received little publicity as yet, though publicly admitted in several manufacturers' statements; several firms correctly foresaw the steel shortage in 1943-44 and began to build up large stocks of steel. This was done by engaging a large buying force—50 buyers in the case of one company, employing 5,000 people—to locate and buy available supplies. Mr. C. W. Reeve, chairman of the Associated Equipment Company, commenting, on December 8, 1947, on the increased difficulties of obtaining balanced material supplies, said: "The course of wisdom which has recommended itself to your Board has been to obtain all available stocks, in the hope that as and when remaining items come in, we shall be able to . . . keep the factory going . . . this not only causes a drain on our financial resources and compels us to have recourse to outside supplies of finance, but it also entails considerable increases in the staff necessary to do what is called the chasing and progress work in the obtaining of these supplies —for our position as manufacturers of heavy motor vehicles is not in any way one of privilege."

The export performance of the industry is set out in Tables IV, V and VI, on page 197, taken from the *Trade and Navigation Returns*, December, 1947. Exports of private cars are shown in Table IV, distinguishing new and second-hand cars, chassis and engines. Exports of commercial vehicles are shown in Table V in a similar manner. Table VI details the value of exports by main countries of destination. A study of this table, which does not include parts, is of particular relevance in view of the importance attached by the Government to exports to "hard-currency" countries, and in the light of the restrictions imposed on the import of cars and, in certain cases, of commercial vehicles, by the Governments of important customer countries. The total value of exports in 1947 was 74·96*l.* million, compared with 15·12*l.* million in 1937, which was one of the peak pre-war years. British countries accounted

for 53·5 per cent. of the exports shown in Table VI, compared with 76 per cent. in 1937. Hard-currency foreign countries accounted for about 15 per cent. of the total, compared with about 5 per cent. exported to the same countries in 1937. Including Canada and the Union of South Africa, hard-currency earnings amounted to some 24 per cent. of the total.

The best customer during 1947 was the Union of South Africa, which took 7·9 per cent. of total exports. Changes in tariff from a weight to an *ad valorem* basis, following the Geneva Trade Conference, led the Society of Motor Manufacturers to express the opinion that the Government had traded away advantages which the British motor industry enjoyed in oversea markets, with negligible benefit to the industry in return. The proposed change in the duty on cars of 400*l.* value and over, f.o.b. imported into South Africa, from 1*l.* 3*s.* for 100 lb. to 20 per cent. *ad valorem*, would have trebled the duty paid by small British cars. Following considerable criticism of this measure, the Union Government agreed to raise the ceiling from 400*l.* to 600*l.*, thus giving more types of cars the benefits of the weight tariff.

In general, the decisions reached at Geneva are considered most injurious to the British motor-vehicle industry. Preferences on British vehicles imported by New Zealand (which accounted for 6·5 per cent of total exports in 1947) are to be reduced, and in India (6·6 per cent.) the preferences on cars are to be reduced at once and eventually eliminated. There are to be general reductions in tariffs on automobile bodies and body panels shipped to Australia (in a few cases, the margins of U.K. preference have been increased), and the preferences on chassis are being reduced.

The most serious news, however, is of the growing restrictions on car imports imposed by various customer countries during the past year. Owing to the closing and shrinkage of markets all over the world on account of exchange and other difficulties, it is estimated that only one third of the world's markets remained open to British cars at the end of 1947. The sellers' market is coming to an end partly because six years' demand is being overtaken and partly because of the competition of other manufacturing countries. A considerable advantage still to be enjoyed by the British industry lies in the exhaustion of world dollar resources, which will not be easily corrected in the face of a United States export surplus of some 10,000 million dollars per annum. In contrast, sterling should be freely available, particularly following on the recent suspension of free convertibility. On the other hand, countries may hesitate to discriminate in their import cuts, and may make reductions in their vehicle imports from all sources. With this in mind, the industry's report to the Minister of Supply, already quoted, states that "wherever possible, imports of British cars should be a definite feature of bi-lateral agreements now under discussion with a number of countries." This, however, may not always prove practicable, as most of the countries involved are suffering from war-shattered economies and tend to "put first things first"—for example, generating plant and railway wagons before motor cars.

The latest available information concerning export markets has given rise to considerable anxiety. Belgium, Holland and Luxemberg have announced a projected restriction on all imports of complete cars in the "Benelux" customs union. One British firm, the British Aeroplane Company, have made arrangements to have their car—a high-quality car which achieved popularity at the Paris Motor Show in October—assembled by a Belgian firm which is already assembling Packards. Holland has banned imports of British cars costing more than 250*l.* and American cars costing more than 1,250 dollars (312*l.*). Belgium and Holland took over 13 per cent. of the total British exports during 1947. Denmark, the best European market before the war, stopped all imports of cars from Britain and restricted the import of commercial vehicles. India which took 6·6 per cent. of the total exports in 1947, has also stopped imports of British cars, and shows no sign of relaxing the ban. Argentina, Mexico, and Czechoslovakia have also banned car imports, and several other countries have imposed price ceilings on imported cars, ranging from 250*l.* to 500*l.*, or have tightened up the issue of import licences. France, which imported American cars to the value of 25*l.* million during the first eleven months of 1947, has also stopped imports from the United States. The only good news comes from Australia and New Zealand; Australia agreed to accept 58,000 British cars during 1948 to counteract the loss of American cars due to the dollar shortage, compared with 19,000 in 1947, and New Zealand decided to double imports of commercial vehicles during the current year. No provision was made for an increase in private-car imports into New Zealand.

British manufacturers have displayed considerable activity in overseas markets during the past year, particularly in those traditionally regarded as closed to British cars. Mr. L. P. Lord, who spent much time in the United States, commented that "although we may not derive much direct profit from our activities, we shall gain indirectly by the extra volume of production at Longbridge, and we shall bring to England many millions of dollars"; and Lord Nuffield announced in December that his organisation would devote 1*l.* million to promoting overseas sales. At present, British car sales to the United States average about 1,000 a month.

The figures for the exports of leading manufacturing countries are shown in Table VII, opposite. For comparison with this table, it may be noted that American exports during 1947 are estimated at 259·5*l.* million, compared with British exports of 74·9*l.* million. The American industry accounted for over 71 per cent. of commercial-vehicle exports in that year (170,976), deriving considerable benefits from the long-term credits it is able to offer—in many cases, up to three years—while British companies are obliged, for lack of financial resources, to insist on cash on delivery. American vehicles also benefit from their suitability for many markets such as Latin America, South Africa, Australia, etc. British difficulties are outlined in the following extract from the statement by Mr. C. W. Reeve, already mentioned: "The hopes we had of simplifying production for the home market have not materialised. The 8 ft. wide public-service vehicle—now officially permitted to be used, subject to approval by the Road Traffic Commissioners—has not made itself felt in the alleviation of passenger-carrying problems as much as we had hoped, because of the disinclination displayed by Traffic Commissioners to its introduction into their respective districts. We are, therefore, still faced with the necessity of having to manufacture our passenger-carrying vehicles, even for the home market, in two different widths, namely, 7 ft. 6 in. and 8 ft." The price factor should not be overlooked. The average 1947 f.o.b. export values of cars (281*l.*) and those of commercial vehicles (389*l.*) were respectively 12 per cent. and 10 per cent. greater than in 1946.

INCREASE IN ZINC PRICES.—The Minister of Supply has issued the Control of Non-Ferrous Metals (No. 31) (Copper, Lead and Zinc) Order, 1948. This Order increases the maximum prices of zinc and zinc sheets by 5*l.* a ton and of zinc oxide by 4*l.* 5*s.* 0*d.* a ton. The increases in price follow the recent rise in the American market price, which affects the Ministry's buying prices for overseas supplies of zinc metal.

MANCHESTER JOINT RESEARCH COUNCIL.—At the annual meeting of the Manchester Joint Research Council, held in the University of Manchester, on February 16, Sir E. Raymond Streat, C.B.E., was unanimously elected chairman and Sir Charles G. Renold, J.P., honorary treasurer. These officers replace Mr. A. H. S. Hinchliffe, D.L., J.P., the past chairman, and Sir John S. B. Stopford, M.D., Sc.D., F.R.S., the past honorary treasurer, who had held office since the formation of the Council by Manchester University and Manchester Chamber of Commerce some three years ago. Both Mr. Hinchliffe and Sir John Stopford were elected vice-chairmen at the meeting. Announcing the establishment of the Manchester Joint Research Council on page 133 of vol. 158 of ENGINEERING (1944), we stated that its main objects would be to encourage and facilitate research; to initiate discussions leading to special inquiries and investigations, including economic and sociological questions; and to engage in activities to bring science and industry into closer relationship.

REINFORCED-CONCRETE LOCOMOTIVE SHEDS.

THE London Midland Region of British Railways (formerly the London Midland and Scottish Railway), have nearly completed the re-roofing of 28 straight and 13 "round-house" locomotive sheds, which accommodate 1,200 engines. A series of pre-cast concrete units has been used for this purpose, and for the complete construction of two new round-houses at Leicester and Carlisle. An aerial photograph of the Leicester shed is reproduced in Fig. 1, on page 200, and the shed at Chester, which has been re-roofed, is illustrated in Fig. 2. Owing to the conditions during the war, when the designs were prepared, pre-cast concrete units were used because they required a minimum amount of the materials which were then in short supply, a considerable degree of pre-fabrication was possible, and consequently the labour required on the site was reduced to a minimum.

The company had been improving their locomotive sheds for a considerable number of years before the war. The work was generally confined to improvements in track layout, and the provision of modern coal- and ash-handling plant. At Carlisle and Leicester, however, it was necessary to build new sheds, and the operating department decided that their requirements could only be met by the provision of round-houses. For this purpose, it was found possible to use the standard pre-cast concrete units which had been developed for re-roofing sheds; therefore, before giving an account of the work at Carlisle and Leicester, the design and use of these units will be described. Indirectly, they had their origin in the national economic crisis of the early 1930's. Maintenance of railway structures had been deferred, and the ill effects of this policy were becoming apparent when war broke out in 1939.

Engine sheds deteriorate more rapidly than other railway buildings, owing to the effect of the steam-laden sulphurous atmosphere on most building materials, The increased railway traffic due to war accelerated the deterioration of roofs, and the company were obliged to reconsider the question of renewals at a time when there was a shortage of labour and materials. The design of roofs prior to 1939 provided deep continuous smoke-troughs of timber, the troughs being open at the top for the full length, with a canopy of corrugated asbestos cement fixed above the opening. Daylight was admitted to the shed through glass in timber glazing bars on each side of the troughs. This design was generally satisfactory, but owing to the shortage of timber it was necessary to consider alternative materials. A tentative design for a reinforced-concrete roof, cast *in situ*, had been prepared before the war, but as this required a considerable amount of timber, the only other alternative appeared to be pre-cast units. Furthermore, by the use of such units, the time of construction at the site, and the interference with the operation of the shed, would be reduced to a minimum. A design not unlike the existing timber sheds was prepared, and it employed many units of a few standard types, which were readily erected. A completed straight roof, and a round roof in course of erection, are shown in Figs. 8 and 9, respectively, on page 204.

The smoke-extraction properties of the design were studied with models in the wind tunnel at the Derby research laboratory, and, as a result, some slight modifications were made to ensure efficient extraction for all directions of horizontal winds. It was considered that, to obtain satisfactory results with the wind blowing along the length of the troughs, the continuity of the early design of vent would have to be broken, and intermittent vents above continuous smoke troughs were proposed, on the assumption that the turbulence caused by the end walls of the vents would provide the extraction effect. Thus, only half the length of trough was provided with vents, as shown in Fig. 8, and the vents on adjacent troughs were staggered to reduce the blanketing effect when a cross wind is blowing. Tests with the model showed that this object was achieved, but the effect was slightly improved by extending the intermediate cross wall a short amount above the roof (as shown in Fig. 8), and by making it greater in width than the end walls. With a cross wind, the extraction is on the Venturi principle, the smoke-trough sides being closed in at the top to a throat width of 12 in., as will be apparent from Fig. 9. Maximum extraction occurred with a wind approximately 60 deg. to the axis of the trough. When the wind-tunnel tests had been studied and the necessary modifications made to the design, a full-size section was erected in an engine shed and tested under practical conditions.

The London Midland and Scottish Railway having been formed from the amalgamation of a number of smaller companies, there were several types of sheds throughout the system. In most cases, the walls, pits, etc., were in relatively sound condition, the deterioration being confined to the roof; and it was necessary, therefore, to design the roofs to suit the existing structures. There were three main types of shed to consider:

the straight shed with parallel roads, generally covered by a north-light type of roof; the straight shed with parallel roads, covered by queen-post or similar type roof; and the so-called "round-house," which was usually a square building with a turntable in the centre, generally covered by three parallel spans. Most sheds were of the first type, with roof columns between alternate rows of parallel tracks; and a standard design of roof, employing only seven principal types of pre-cast units, was prepared to suit this class of shed. Longitudinal- and cross-sections of a roof of this design at Stafford shed, are shown in Figs. 3, 4 and 5, opposite.

A typical reinforced-concrete column is 1 ft. square in section, and 18 ft. 9 in. in length, with the thickness at the top end increased to 2 ft. for a length of 1 ft. 9 in. It is reinforced with a pair of hairpin-shape rods, 1¼ in. in diameter, along the length of the column, and 28 evenly-spaced rods ⅜ in. in diameter, each bent into a square and wrapped round the longitudinal rods. There is also additional reinforcement at the top of the column. The weight of steel is 346 lb., the volume of concrete is 18·6 cub. ft., and the total weight of one column is 28 cwt. A typical beam unit is 2 ft. 9 in. in depth, 1 ft. thick, and about 28 ft. long, with reinforcement of 1 in. longitudinal rods and ⅜ in. wrapping rods. There are two longitudinal rods near the upper edge, and six longitudinal rods near the lower edge. The shape of a smoke curtain will be apparent from the section of smoke trough which is shown erected in Fig. 9, and from the view from below of a partly-constructed roof in Fig. 10, which is also on page 204. Two curtain units make a section of trough, and each curtain is curved on the inner face, towards the top (to form the throat), and is provided with square holes at 2-ft. centres to accommodate the glazing bars (Figs. 8 and 9). They are designed as simple beams, and are not usually joined to form a continuous beam after erection. The weight of reinforcement in each curtain is 172 lb., the volume of concrete is about 40 cub. ft., and the total weight is 2 tons 15 cwt. The length of a curtain is 15 ft. 11½ in., and the depth is 8 ft. Four well-greased eye-bolts with tapered nuts are cast-in to facilitate lifting. The gutter units, which act as beams to support the lower ends of the glazing bars, are also 15 ft. 11½ in. in length, and the cross-section is in the form of a thick channel, 2 ft. 3 in. wide outside, and 1 ft. 2 in. wide inside. The total weight of one gutter unit is approximately 1 ton 7 cwt. The other principal units, the shapes of which will be apparent from Fig 8, are the glazing bars, the slabs which cover the troughs between the vents, and the components of the vents, the shape of the vent roofs assisting the venturi effect. The only alterations required to make these standard units fit a large number of sheds were slight increases in the lengths of the beams and glazing bars. In one case, where the shed varied considerably from the usual design, pre-cast slabs were provided as filling-in pieces for the roof, as the width between the roads was too great to be covered economically with glazing.

The columns in the typical straight shed which is shown in Figs. 3, 4 and 5, are spaced at approximately 16-ft. centres longitudinally, usually in the space between each pair of engine roads, and are fixed in sockets provided in an *in-situ* foundation block. The roof structure is supported by transverse beams which rest on the columns. When two beams have been placed in line on a common column, the joint is concreted, using steel forms, and reinforcement is placed at the top of the joint to withstand any reverse moment over the column. Nevertheless, because most of the dead load is applied to the beams before the joint is made, they are designed as simple beams. The gutter beams and smoke curtains are supported by, and fixed to, the transverse beams; the glazing bars span between the curtains and gutters, the width varying from 3 ft. to 4 ft. 6 in., according to the existing dimensions of the shed.

While the straight sheds which previously had north-light roofs could be re-roofed by this standard method, there were some existing sheds covered by roofs of greater spans, where the operating department could not agree to the provision of columns in alternate roads, owing to the restricted space. In such cases, the cross-section of the beams was increased to enable them to span three roads and support three instead of two rows of smoke troughs. For the shed at Chester, however, where there are eight parallel roads, only one row of columns could be used, and the transverse beams were required to span four roads. The dimensions of the standard smoke curtains fixed the maximum allowable depth of the beams at 2 ft. 9 in., and support for the roof was provided by a series of rigid frames, each consisting of two continuous 59-ft. spans at 16-ft. centres, with the outer columns placed outside the existing walls of the shed. This is shown in Fig. 2, but the end beams are lower than the other beams in the shed, which are not visible. The beams and columns were cast separately and joints made *in situ* to ensure continuity. As operating requirements prevented the use of scaffolding, the beams were supported on the columns by temporary steel structures, which were bolted to the beams and supported the form-work for the joint until the concrete had set.

REINFORCED-CONCRETE LOCOMOTIVE SHEDS.

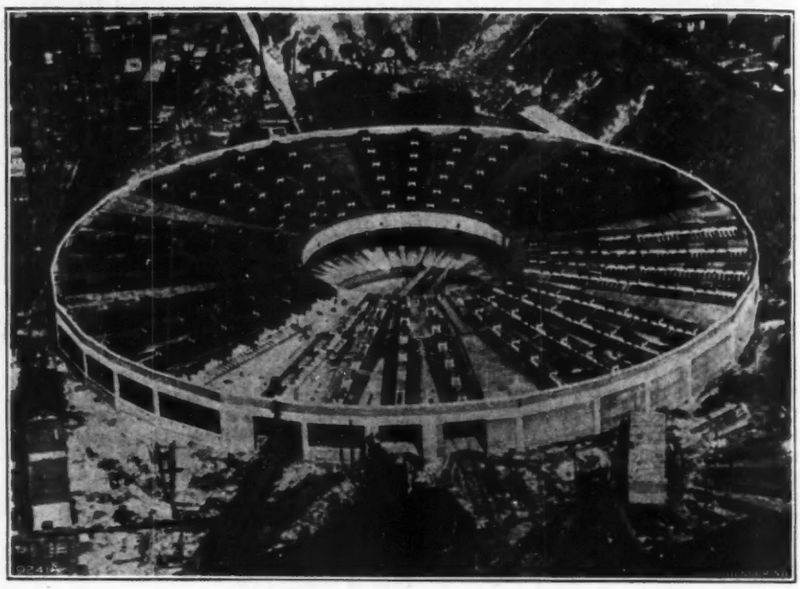


FIG. 1. LEICESTER ROUND-HOUSE.

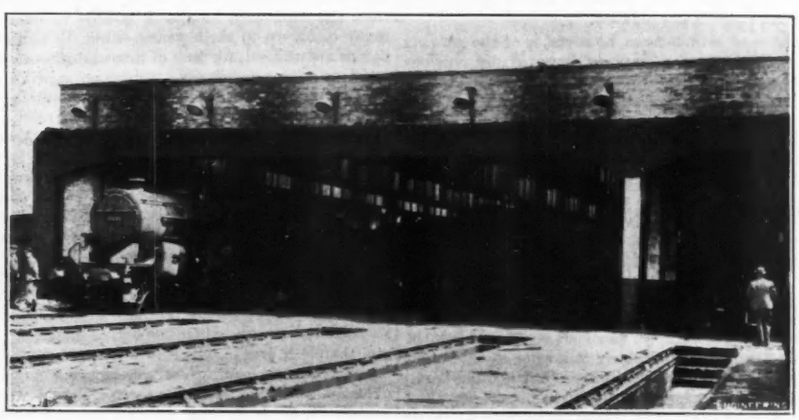


FIG. 2. REINFORCED-CONCRETE ROOF AT CHESTER.

Previous experience had indicated that properly cured concrete was reasonably resistant to attack from smoke fumes, especially if the extraction of smoke was efficient. The coal used during the war, however, was of inferior quality, and the concrete in smoke troughs was affected. The Company's research department recommended the application of two coats of bituminous solution, and this proved effective in protecting the concrete and preventing condensation.

When the design had been successfully applied to straight sheds, "round-house" sheds were examined to ascertain the possibility of applying the standard units. It was decided that this could be done, but the problem was complicated by the necessity for providing cover over the turntable. Such sheds are usually square and the roads vary in length; and to make the maximum use of the roads, engines are often stabled close to the turntable. The diameter of the turntables is generally between 50 ft. and 60 ft., and it was decided to cover the opening by a rectangular roof of pre-cast concrete units, 65 ft. by 51 ft., supported by four pre-cast concrete tied-arch units. Several of these units, which weigh approximately 11 tons each, are shown in Fig. 11, on page 204. Two half sections, at right-angles, of the Belle Vue shed, which was re-roofed in this manner, are shown in Fig. 6, opposite. The arch units are supported on four steel-plate beams encased in concrete, and arranged in a rectangle over the turntable, with a concrete-encased stanchion at each corner. The shed is approximately 180 ft. square, and the remainder of the roof is supported by beams arranged radially and concentrically, the latter supporting the smoke curtains. The tapered areas of the roof were covered with concrete slabs, arranged to drain into the gutters, and designed to reduce the number of special shapes to a minimum. Of the 13 round-houses which are being re-roofed, about half are sufficiently alike to enable the units to be made with only minor variations. For the remainder, modifications were introduced to take account of such factors as variation of the angle between the roads, the effect of adjoining sheds, and the accommodation of high sheer-legs, for which it was generally necessary to construct a section of roof which was higher than the general level.

The usual method of re-roofing a shed is to demolish the existing structure over two roads, and erect the new units with a 10-ton travelling crane, completing the full length of one bay before proceeding to the adjacent bay. The rate of re-roofing obviously depends on local circumstances, but up to six sections (each approximately 25 ft. wide, across two tracks, and 16 ft. long), can be erected in one week. The gutters are lined with two layers of bitumen felt, and the vent and trough covers are also protected by this material. The glass is fixed into the concrete glazing bars with a plastic bitumen compound, the density of which is thicker where it is used for bedding the glass than where it is used for pointing. To avoid leakage, the pointing is continued over the tops of the bars. The gutter units are laid without fall, but cast-iron outlets and gratings are fixed into them at suitable intervals, and connected to asbestos-cement down-pipes (bitumen-dipped), which are grouped round vertical pipes fixed to the columns. Owing to the size and shape of the smoke-trough units, special provision was made for transport

REINFORCED-CONCRETE LOCOMOTIVE SHEDS.

Fig. 3. SECTION AA

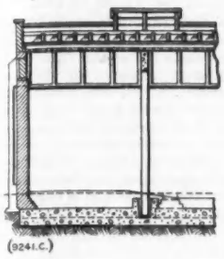


Fig. 4. SECTION BB

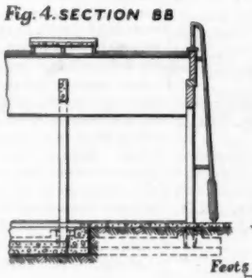


Fig. 5.

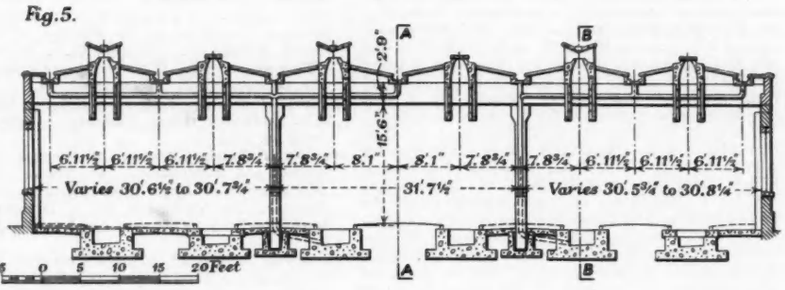


Fig. 6.

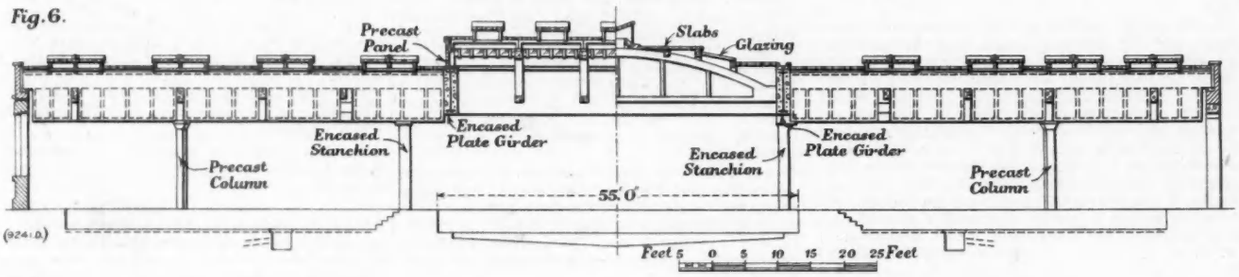
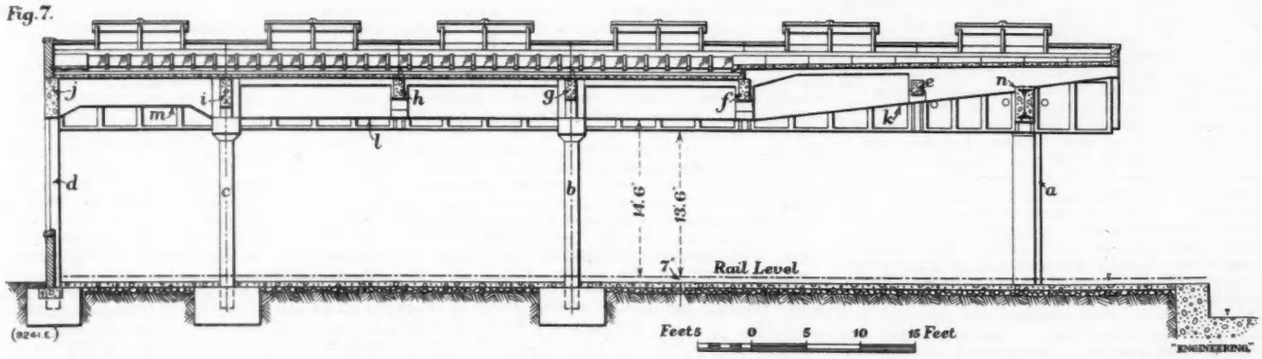


Fig. 7.



to the site. Normally, there are two pairs of units to each bay, and suitable steel frames were designed and fixed in 12-ton flat wagons, so that four units could be transported in the same relative positions as they would occupy when erected in the roof. On arrival at the site, the four units were lifted out, using special lifting tackle, and hoisted directly from the wagon to the correct positions in the roof.

The two new round-houses at Leicester and Carlisle each have 32 roads of equal length, radiating from a 70-ft. diameter turntable, and the overall diameter of the structure is approximately 290 ft. The roof is constructed largely of the standard units, already described, and the total weight of pre-cast concrete in the roof is 3,600 tons, including 195 tons of reinforcing steel. Owing to the size of the turntable and the number of radial roads, it was difficult to find space for roof supports, and it was therefore decided that the turntable should not be roofed. The roads are arranged in eight groups of four, with a wider angle between each group than between a pair of roads in a group. This arrangement allows eight columns to be erected as near as possible to the turntable, one in each wider angle. A half-radial section between a pair of roads in a group (*i.e.*, through the gutter slabs in the roof), at the Leicester round-house, is shown in Fig. 7, on this page. There are eight main columns *a*, on a pitch-circle diameter of 112 ft.; it was not possible to place them any closer to the turntable because clearance, depending on the loading gauge, is required between the columns and the roads on each side. There are 32 each of columns *b*, *c* and *d*, between each pair of roads. The roof is supported on a series of beams, *e*, *f*, *g*, *h*, *i* and *j*, arranged in the form of concentric polygons. These beams rest on a series of radial beams, *k*, *l*, and *m*, which, in turn, are supported on the columns; except that the inner ends of beams *k* rest on the eight main ring beams *n*, which span between the eight main columns *a*.

Columns and beams are of reinforced concrete, except that columns *a* and beams *n* are, respectively, structural steel and steel-plate girders, encased in concrete. Each main beam *n* is 42 ft. in length and weighs 19 tons 10 cwt.; and each column *a* weighs 3 tons 12 cwt. Owing to the very heavy load between these beams and columns, cast-iron rockers are provided. The radial beams *k* are cantilevered towards the turntable to make the hole in the roof as small as possible, and the heaviest of these beams weighs 12 tons 11 cwt., and is 50 ft. in length. The ring beams *e*, *f*, *g*, *h*, *i* and *j*, vary in length, and in weight from 17 cwt. to 10 tons 2 cwt., according to position. The construction of the round-house roof will be apparent from Fig. 9, which shows the principal units being erected; and it will be seen from this, and from the aerial view reproduced in Fig. 1, that the "round-house" is more accurately a 32-sided polygon. Fig. 10 is a view of the beams, columns and smoke curtains taken from below. The standard units which were developed for the re-roofing of sheds, were employed for the roofs of the two new round-houses, but in the latter case additional special units were also required. The glazing on each side of the smoke troughs extends from the outer wall for about two-thirds of the distance to the turntable opening, as will be apparent from Fig. 1, and the radial section in Fig. 7.

The upper half of the wall of the round-house at Leicester is glazed to provide adequate daylight at the ends of the roads, and the lower half is built of brick. The ring beams *j* support a low brick parapet around the roof, enclosing the ends of the smoke troughs. The wall of the Carlisle round-house is built of *in-situ* concrete, and pre-cast units are used for the parapet. In both sheds, one sector is used for stabling engines under repair, and for this purpose the area is enclosed by radial brick walls with sliding doors at the entrance.

All roads in the round-house are provided with pits 78 ft. in length. As it was difficult to obtain bricks and bricklayers, and as timber for form-work was also in short supply, it was decided to construct the pits in pre-cast concrete; and a standard U-section unit, 6 ft. long, weighing approximately 3 tons, was designed. The units are laid end to end in a trench, and a connection to resist shear is made by inserting a pre-cast concrete key in suitable recesses in the ends, and grouting it in position. Pre-cast blocks, 6 ft. long are laid along the top edges of the units, with the joints staggered, and standard rail chairs are fastened to these blocks. The pits are drained through the walls into sumps between the tracks. The concrete units are readily erected and have the additional advantage that they are easy to keep clean, in which condition they provide a good reflecting surface. In some of the pits, lighting is provided by fluorescent tubes at 9-ft. centres, the wiring being carried in conduits cast in the units.

The floor of the round-house is of *in-situ* concrete, 7 in. thick, level with the underside of the chairs. Around the turntable pit, however, the floor is level with the tops of the rails, to allow hand-carts to be moved about the shed, using the turntable for this purpose, and there are ramps connecting the two levels. A 5-in. diameter ring main supported on the roof beams, with pipes and cocks on some of the columns, is used for supplying water for washing-out, etc. The wiring for the general electric lighting is carried in asbestos-cement tubes through the smoke troughs. A group of buildings is being constructed adjacent to the round-house to provide stores, workshops, offices and staff facilities.

The round-houses were erected in a similar manner to that already described for the straight sheds. Approximately 10,000 units were required for the Carlisle round-house, and they were erected in nine months, despite a delay of five weeks due to bad weather, by 27 men, including those who laid the pits and concreted the floor. Owing to the size of the radial cantilever beams, it was necessary to fit a wagon with a steel frame, which accommodated three beams for transport to the site. On arrival, they were lifted by a railway breakdown crane, directly from the wagon on to the tops of the columns. A small travelling crane was used for the remainder of the re-roofing. The concrete units for both round-houses were supplied by the Empire Stone Company, Limited, Narborough, Leicestershire. Messrs. Tersons, 2, Seward-street, London, E.C.1, erected the Leicester round-house, and railway staff carried out the work at Carlisle.

THE INSTITUTE OF METALS.

THE annual general meeting of the Institute of Metals will be held at the Institution of Civil Engineers, Great George-street, London, S.W.1, on Tuesday, Wednesday and Thursday, March 16, 17 and 18. The meeting will open at 2.30 p.m., on March 16, when Dr. M. Cook and Mr. E. C. Larke will present, for discussion, a paper entitled "Calculation of Loads Involved in Metal Strip Rolling." This will be followed by a joint discussion on two papers, the first by Dr. P. H. Jennings, Dr. A. R. E. Singer and Mr. W. I. Pumphrey, on "Hot-Shortness of Some High-Purity Alloys in the Systems Aluminium-Copper-Silicon and Aluminium-Magnesium-Silicon," and the second, by Dr. P. H. Jennings and Mr. W. I. Pumphrey, on "A consideration of the Constitution of Aluminium-Iron-Silicon Alloys and its Relation to Cracking above the Solidus." If time permits, a paper by Mr. D. McLean on "Striations: Metallographic Evidence of Slip," will be presented and discussed and the meeting will be adjourned at 5 p.m.

On the second day, at 10 a.m., the reports of the Council and of the honorary treasurer will be presented and announcements made regarding the election of officers for 1948-49 and concerning the award of the Institute of Metals Platinum Medal for 1948. After this, Sir Arthur Smout, J.P., will be inducted as President and will deliver his Presidential Address. The meeting will be adjourned at 12.30 p.m., and will be resumed at 2.30 p.m. Two papers are on the agenda for discussion during the afternoon meeting, namely, "The Effects of Single- and Multi-Hole Die Extrusion on the Properties of Extruded Aluminium-Alloy Bar," by Dr. L. Northcott, Mr. D. McLean and Dr. O. R. J. Lee; and "The Young's Modulus of Some Aluminium Alloys," by Miss N. Dudzinski, Mr. J. R. Murray, Mr. B. W. Mott and Dr. B. Chalmers. The meeting will be adjourned at 5.0 p.m., and at 7.30 p.m. a buffet dance will be held at 4, Grosvenor-gardens, London, S.W.1.

The meeting will be resumed at 10.0 a.m., on the third day, Thursday, March 18, when two papers will be discussed, namely, "Pressure and Creep Tests at Constant Hoop Stress on Lead and Alloy 'E' Pipes," by Dr. A. Latin; and "Recent Developments in Corrosion-Resistant Aluminium-Magnesium Alloys," by Dr. P. Brenner and Dr. W. Roth. The meeting will conclude at 12.30 p.m., and the afternoon will be devoted to visits to the works of Messrs. A.P.V. Company, Limited, Wandsworth, London, S.W.18; Enfield Rolling Mills, Limited, and Enfield Cables, Limited, Brimsdown, Enfield, Middlesex; High Duty Alloys, Limited, Slough, Buckinghamshire; Murex Limited, Rainham, Essex; Murex Welding Processes, Limited, Waltham Cross, Hertfordshire; and J. Stone and Company, Limited, Charlton, London, S.E.7. The offices of the Institute of Metals are at 4, Grosvenor-gardens, London, S.W.1.

LAUNCHES AND TRIAL TRIPS.

M.S. "SEKONDI."—Single-screw cargo vessel, with provision for the carriage of 972 tons of palm oil; built by the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees, Co. Durham, for the African Coast trade of Messrs. Elder Dempster Lines, Limited, Water-street, Liverpool, 2. Main dimensions: 385 ft. by 57 ft. by 32 ft. 9 in. to shelter deck; deadweight capacity, 6,211 tons on a draught of 22 ft. 3½ in. Doxford-type four-cylinder opposed-piston oil engine of 3,100 brake horse-power, built and installed by Messrs. Richardsons, Westgarth and Company, Limited, Hartlepool, Sunderland, giving a maximum speed of 14·3 knots in ballast condition. Trial trip, February 3.

M.S. "BOREALIS."—Single-screw vessel for the fruit-carrying trade from Mediterranean ports, with accommodation for twelve passengers. Built by Messrs. Smith's Dock Company, Limited, South Bank Shipyard, Middlesbrough, for Messrs. Den Norske Middelhavslinje A/S. (Fred. Olsen and Company), Oslo, Norway. Main dimensions: 350 ft. by 53 ft. by 31 ft. to upper deck; deadweight capacity, 4,266 tons on a draught of 20 ft. 4½ in. Four-cylinder opposed-piston airless-injection Doxford oil engine, built and installed by Messrs. North Eastern Marine Engineering Company (1938), Limited, Wallsend-on-Tyne, giving a service speed, fully loaded, of about 14 knots. Trial trip, February 3.

M.S. "CORAMBA."—Single-screw vessel for the carriage of cargo, including petrol in tins, refrigerated and special cargoes, on the Australian coast trade. Accommodation is provided for three passengers. Built by Messrs. Short Brothers, Limited, Pallion, Sunderland, to the order of the Australasian United Steam Navigation Company, Limited, Leadenhall-street, London, E.C.3. Main dimensions: 382 ft. 6 in. by 51 ft. 9 in. by 34 ft.; deadweight capacity, 5,500 tons on a mean draught of 22 ft. 7 in. Four-cylinder opposed-piston two-stroke oil engine supplied by Messrs. William Doxford and Sons, Limited, Pallion, Sunderland, to give a service speed of 12 knots. Trial trip, February 7.

BOOKS RECEIVED.

Ministry of Fuel and Power, and British Intelligence Objectives Sub-Committee. Technical Report on the Ruhr Coalfield. By a Mission from the Mechanisation Advisory Committee of the Ministry of Fuel and Power. Volume III. Appendix No. 3. *Walsum Mine—Technical Details.* H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*s.* 6*d.* net.]

Ministry of Works. Temporary Housing Programme. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 3*d.* net.]

Ministry of Supply. Aeronautical Research Committee. Reports and Memoranda. No. 2000. *Mechanical Admittances and Their Applications to Oscillation Problems.* By PROFESSOR W. J. DUNCAN. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 22*s.* 6*d.* net.]

Engineering Applications of Fluid Mechanics. By J. C. HUNSAKER and B. G. RIGHTMIRE. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 5 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 30*s.*]

Engineering Organisation and Methods. by JAMES E. THOMPSON. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 4 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 24*s.*]

Materials Handbook. An Encyclopedia for Purchasing Agents, Engineers, Executives and Foremen. By GEORGE S. BRADY. Sixth edition. McGraw-Hill Book Company, Incorporated, 330, West 42nd-street, New York 18, U.S.A. [Price 7 dols.] McGraw-Hill Publishing Company, Limited, Aldwych House, Aldwych, London, W.C.2. [Price 42*s.*]

Working Conditions in the Civil Service. Report by a Study Group Appointed by H.M. Treasury. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 4*s.* net.]

Department of Scientific and Industrial Research. Fuel Research. The Winning, Harvesting and Utilisation of Peat. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 6*d.* net.]

The Efficient Use of Steam. Written for the Fuel Efficiency Committee of the Ministry of Fuel and Power, by OLIVER LYLE. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 15*s.* net.]

The British Electrical and Allied Industries Research Association. Twenty-Seventh Annual Report, October 1, 1946, *to September* 30, 1947. Offices of the Association, 15, Savoy-street, Strand, London, W.C.2. [Free to approved applicants.]

Metal Spraying and Sprayed Metal. Third edition, rewritten by W. E. BALLARD. Based on previous editions by DR. E. C. ROLLASON, T. HENRY TURNER and DR. N. F. BUDGEN. Charles Griffin and Company, Limited, 42, Drury-lane, London, W.C.2. [Price 32*s.* net.]

The Differential Analyser. By J. CRANK. Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1. [Price 10*s.* 6*d.* net.]

Electro-Technology for National Certificate Students. Volume I. By H. TEASDALE and DR. E. C. WALTON. The English Universities Press, Limited, Saint Paul's House, Warwick-square, London, E.C.4. [Price 9*s.* 6*d.* net.]

Locomotive Management. Cleaning, Driving, Maintenance. By JAS. T. HODGSON and CHAS. S. LAKE. Ninth edition. Revised by CHARLES E. LEE. The St. Margaret's Technical Press, Limited, 33, Tothill-street, Westminster, London, S.W.1. [Price 10*s.* net.]

Smithsonian Institution. Publication No. 3876. *Visible Patterns of Sound.* By R. K. POTTER. The Director, Smithsonian Institution, Washington, D.C., U.S.A.

Applied Plastic Product Design. A Simplified Presentation of Plastic Design Principles. By ROBERT L. DAVIS and RONALD D. BECK. Prentice-Hall, Incorporated, 70, Fifth-avenue, New York, U.S.A. [Price 4.70 dols.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 28*s.* net.]

Introduction to Atomic Physics. Revised and enlarged. By PROFESSOR HENRY SEMAT. Rinehart and Company, Incorporated, New York. [Price 4 dols.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 24*s.* net.]

Production Engineering: Jig and Tool Design. By E. J. H. JONES. Fifth edition. George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2. [Price 17*s.* 6*d.* net.]

Gear Trains, Including a Brocot Table of Decimal Equivalents and a Table of Factors of All Useful Numbers up to 200,000. By DR. H. E. MERRITT. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 30*s.* net.]

The United Steel Companies Limited. Advanced Industrial First-Aid. 1947. By R. A. TREVETHICK. Obtainable from Henry Garnett and Company, Limited, "Advertiser" Office, Rotherham, Yorks. [Price 3*s.*]

PERSONAL.

SIR RICHARD SOUTHWELL, F.R.S., Rector of Imperial College of Science and Technology, South Kensington, London, S.W.7, since 1942, is retiring from that office on September 30, 1948, having asked leave to decline the proposal of the Governing Body of the College to prolong the term of his appointment.

MR. ERNEST L. JACOBS, chairman of the Subcommittees of Classification, Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, has relinquished this position on account of advancing years. MR. K. R. PELLY, M.C., who has been deputy-chairman and treasurer since July, 1946, has been elected to succeed Mr. Jacobs as chairman of the Subcommittees of Classification. SIR PHILIP D'AMBRUMENIL has been elected deputy-chairman and treasurer in place of Mr. Pelly.

MR. J. TAYLOR THOMPSON, M.C., M.I.C.E., civil engineer, North Eastern Region, British Railways, with headquarters at York, has been elected President of the Permanent Way Institution.

MR. A. D. SLOAN, M.I.E.E., chief engineer of the English Electric Company Limited, Stafford, since 1936, has retired. His successor as chief engineer is MR. J. T. MOORE.

MR. W. N. MCCLEAN, M.A. (Cantab.), A.M.I.C.E., has been elected an honorary member of the Institution of Water Engineers.

DR. A. J. GOULD has been appointed senior lecturer in the Department of Glass Technology, University of Sheffield.

MR. A. B. BALDWIN, M.Eng. (L'pool), A.M.I.C.E., A.M.I.W.E., has been appointed water engineer of Shrewsbury in succession to MR. R. D. ROBINSON, B.Eng. (L'pool), A.M.I.C.E., M.I.W.E., who has relinquished the appointment to become a partner in the firm of Messrs. G. H. Hill and Sons, consulting engineers, 51, Mosley-street, Manchester, 2.

COLONEL T. C. A. CLARKE, D.S.O., A.M.I.Mech.E., Royal Tank Regiment, has been appointed chief instructor at the Driving and Maintenance Wing, Royal Armoured Corps School, Bovington, Wareham, Dorset.

MR. C. H. MARKS, B.Sc.Tech. (Manch.), A.M.I.Mech.E., has been appointed technical consultant to Messrs. Powell Duffryn Technical Services, Limited.

DR. H. FORD, B.Sc. (Eng.) (Lond.), Wh.Sc., M.I.Mech.E., has been elected a director of the Paterson Engineering Company, Limited.

MR. V. A. B. HUGHES, M.I.Mech.E., has joined the board of the Chloride Electrical Storage Company, Limited, Manchester.

MR. VICTOR W. BONE, J.P., M.I.Mech.E., managing director of Ruston and Hornsby, Limited, Lincoln, has been elected to the additional appointment of chairman of the company, in succession to the late MR. G. R. SHARPLEY. Mr. Bone is a director of Ruston-Bucyrus Limited, and Ransomes, Sims and Jefferies, Limited, a director and vice-chairman of Davey, Paxman and Company, Limited, and a director and chairman of F. H. Lloyd and Company, Limited.

MR. FRANK W. BELL, A.M.I.Mech.E., export manager of Robey and Company, Limited, Globe Works, Lincoln, has been appointed a director of the company.

Pending the appointment of a successor to MR. A. HENDERSON, M.Inst.T., now a full-time member of the Road Transport Executive, British Transport Commission, MR. S. W. NELSON, M.Inst.T., the licensing authority for goods vehicles for the Northern Traffic Area, will act, for the time being, in a similar capacity for the Traffic Area for Scotland.

MR. P. A. JOB is relinquishing the position of general works manager of the Llanelly Steel Company, Limited, but is retaining his seat on the board of directors.

MR. W. A. SMITH, B.Sc., A.R.T.C., has left Corby, where he held a position on the staff of the general manager's department, Messrs. Stewarts and Lloyds, Limited. He has now taken up a post in the company's Department of Research and Technical Development, Clyde Tube Works, Coatbridge, Lanarkshire.

MR. S. H. FREDERICK has joined the staff of the Pametrada Research Station, Wallsend-on-Tyne, as metallurgist.

MESSRS. BUTTERS BROTHERS AND COMPANY, LIMITED, have opened a new North-East Coast office at 65, Quayside, Newcastle-upon-Tyne. (Telephone: Newcastle 21067.)

MESSRS. E. R. WATTS AND SON, LIMITED, and MESSRS. ADAM HILGER LIMITED, are being formed into one company registered as MESSRS. HILGER AND WATTS LIMITED. The board of directors of the new company is an amalgamation of the boards of Messrs. A. Hilger and Messrs. E. R. Watts, namely: MR. G. A. WHIPPLE, M.A., M.I.E.E., chairman and managing director; MR. F. TWYMAN, F.R.S., technical adviser; DR. A. C. MENZIES, controller of research; MR. D. R. STANLEY, controller of sales; MR. V. W. H. TOWNS, technical controller; and MR. R. H. WATTS, assistant controller of sales.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—Disappointment was felt by Scottish steelmakers this week when two furnaces at Colvilles' Dalzell Works and one at the Lanarkshire Steel Works had to be laid off owing to insufficient scrap. A serious view of the development is being taken by Scottish industries other than steelmaking in the light of official appeals for increased production and the dependence of Scottish industrial activity on steel. Hopes of any great assistance from increased scrap tonnages from Germany have been receding rapidly, and more reliance is being placed on improved local collection. Happily, pig-iron production has been more steadily maintained. Some improvement has been effected at Colvilles' Tollcross Works in connection with the operation of the new blast-furnace, and outputs have been better. Still greater outputs could be obtained if metallurgical coke supplies were raised. Regular cargoes of iron ore have been discharging on the Clyde, while the delivery of limestone has been adequate. In the event of further deterioration of scrap supplies, increasing use of pig-iron in the steel-furnace charges will have to be made. Consumers have been supplied fairly satisfactorily with slabs and billets. Sheet bars have continued short of requirements, and rivet, nut, and bolt makers have been perturbed at the scarcity of sizes of 3-in. square and under, necessary for the manufacture of these components. The demand for light-gauge sheets has been almost insatiable, and users of sheets under No. 12 gauge, in particular, have not always been able to secure tonnage for priority orders.

Scottish Coal.—The recovery in deep-mine production in the second week of February was only slightly greater than the decline in the preceding week. Provisional figures were 482,900 tons, the second highest total of 1948, compared with a corrected return of 463,500 tons in the week ended February 7. Area tonnages, at 145,100 in the second week, exceeded the weekly average of the previous fortnight by only some 4,000 tons, compared with the fall of 11,800 tons in the first week. Outputs in Ayrshire and the Lothians registered the customary fortnightly increase, amounting on this occasion to 6,600 tons. Lanarkshire production was lower by 2,500 tons as a result of a week's idleness at Priory Colliery. The recent spell of cold weather increased coal consumption for space-heating in particular. Gas and electricity requirements increased also, but regular deliveries and good stocks ensured adequate supplies. Washed grades were in increasing demand from industrial users, but the supply was inadequate. Anthracite continues short of requirements, but seasonal demands from fruit-growers were met in accordance with the class priority. Metallurgical coke outputs have been fairly constant, and supplementary deliveries from England have been arriving regularly. Principal loadings in the export trade have included cargoes for Sweden and regular shipments to Eire. Exporters are hoping to arrange tonnages for Holland, Denmark, and other countries in the near future.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—Following an outbreak of strikes the South Western Divisional Coal Board have announced that they will take action for breach of contract against strikers. Mr. A. Davies, area President of the Miners' Union, declared that the Board had refrained from this action so far in the hope of reaching a better understanding with the men. The area executive of the Union, to whom the Board communicated their intention before making it public, deplored the wave of stoppages in the coalfield and condemned the action of the strikers. Exporters at Cardiff during the week have felt great concern at the action of the Divisional Coal Board in arranging a cargo of 3,000 tons for France directly with the foreign buyers. The action was in accordance with the declared intention of the Coal Board of reserving for themselves the right to export directly. On the other hand, N.C.B. officials, on a number of occasions, have assured the shippers that they intended to make the fullest possible use of the machinery which the exporters had built up. The supply position has become slightly better in the steam-coal market, following the better trend of outputs. Nevertheless, new business was difficult to arrange, especially for overseas. The requirements of home consumers were heavy and orders in hand from the priority consumers were sufficient to provide a ready outlet for almost the whole of the potential outputs. Cokes and patent fuel attracted a keen interest.

Swansea Steel-Sheet Industry.—The market report issued by the Incorporated Swansea Exchange states that, last week, business in tin-plate was well maintained and makers were able to dispose of their outputs for the current period. The export market was as active as the supply position would allow and a moderate volume of business was transacted. Steel sheets show no change and new business is difficult to negotiate. Iron and steel scrap is in great demand, more particularly the heavier and better qualities.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Iron and steel plants in the Tees-side area continue to achieve record outputs, but the total tonnage production is still considerably short of current requirements. The output of the Cleveland ironstone mines is shrinking and the unsatisfactory yield necessitates the increasing use of costly imported ore. The demand for better supplies of iron and steel scrap is unabated. The gradual replacement of old blast-furnaces by new and larger stacks is proceeding steadily, but the demand for pig iron is still much in excess of supplies. The aggregate tonnage output of steel is on an unprecedented scale, but is far from sufficient for the buyers' needs.

Foundry and Basic Iron.—Foundry operations are still seriously hampered by the shortage of pig iron and the acute scarcity of cast-iron scrap, but every effort is being made to accelerate the collection of the latter. The small, intermittent make of iron suitable for foundry work is being used promptly; parcels of foundry iron coming to hand from other producing areas are inadequate. Basic blast-furnaces are turning out sufficient tonnage for the essential needs of the adjacent steel furnaces, but none is available for use elsewhere.

Hematite, Low-Phosphorus and Refined Iron.—Makers of East-Coast hematite are able to provide their regular customers with sufficient tonnage to cover current requirements, but are unable to supply iron for stock. Low- and medium-phosphorus grades of iron are in steady request and no difficulty is experienced in disposing of the make of refined iron.

Manufactured Iron and Steel.—Semi-finished iron plants are busily engaged and branches turning out finished iron have extensive contracts in hand. Makers of semi-finished steel are providing larger parcels, but the supply is not equal to the demand. Re-rollers need larger quantities of billets, blooms and sheet bars. Finished-steel manufacturers are making heavy deliveries greatly exceeding expectations, but are sold to an extent that prohibits the acceptance of further orders for execution before the second quarter of the year. Export licences for finished commodities are on a restricted scale and the release of commodities for home purposes are much less than the demand. If the present rate of production continues, however, some increase in tonnage allocations may be possible in the near future.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The shortage of supplies of ordinary carbon-steel billets has checked re-rolling operations. It is hoped that a change in methods of allocating steel, due to come into force from April 1, will tend to check maldistribution which is one of the causes of shortages. There are ample supplies of alloy and other special steels to keep the mills operating fully. Some sheet mills need more skilled labour if they are to make the best of the supplies of steel coming forward; some Polish and other foreign labour is doing good work at the mills and forges. Hot- and cold-rolled strip is in strong demand and production is at a high level. Wire-rod rolling mills are operating as fully as supplies of materials permit, and there is activity in the manufacture of wire ropes. Colliery-engineering firms are working well on a large number of contracts for coal-mining machinery and equipment. Railway-material departments are becoming busier as more steel is available, but a scarcity of axle steel continues to hamper operations.

South Yorkshire Coal Trade.—Better supplies have become available in spite of the abandonment of Saturday shifts at 13 collieries. Distribution of coal continues to improve as more wagons are brought back into service from repair shops and more locomotive power is available. A larger proportion of opencast coal, in allocations, has been decided upon, and some protests have been made by merchants and others. The supply of opencast coal has been increased owing to the mild weather, but a recent fall of snow is expected to retard production for a time. Coking-coal allocations are a little more satisfactory, and the make of coke is being fairly well maintained.

REBUILDING A MANCHESTER BRIDGE.—British Railways (London Midland Region), acting for the Manchester Corporation, have placed a contract with Messrs. Thos. Wrigley Limited, Manchester, for the reconstruction of a bridge which carries the Manchester (London Road) to Stockport railway over Albert-road, Levenshulme, to enable double-deck 'buses to use the road. The new bridge will have a span of 36 ft., and headroom of 16 ft. 8 in. To avoid interference with rail traffic, temporary steel trestles and girders will be erected to support the tracks during the demolition, and the early stages of reconstruction.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

SOCIETY OF ENGINEERS.—Monday, March 1, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1. "Oil-Burning Pressure-Jet Installations," by Mr. D. C. Lynn. "Industrial Oil Burners," by Mr. G. M. Davies.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Eastern Branch:* Monday, March 1, 6 p.m. King's College, Newcastle-upon-Tyne. "Possibilities of Nuclear Energy for Heat and Power Production," by Professor J. D. Cockcroft, F.R.S. *Institution:* Friday, March 5, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Wave Action Resulting from Sudden Release of Compressed Gas from a Cylinder," by Dr. F. K. Bannister and Professor G. F. Mucklow. *Southern Branch:* Saturday, March 6, 1 p.m., Kimbell's Restaurant, Southsea. Luncheon. Presidential Address by Lord Dudley Gordon. AUTOMOBILE DIVISION. *London:* Tuesday, March 2, 6 p.m., Storey's-gate, S.W.1. "Large-Scale Vehicle Overhaul and Repair," by Mr. E. C. Ottaway. Also at the *North-Eastern Centre:* Wednesday, March 3, 7.30 p.m., The University, Leeds. *Coventry Centre:* Tuesday, March 2, 7 p.m., Geisha Café, Hertford-street, Coventry. "The Motor Car *versus* the Weather," by Mr. H. Silman.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, March 1, 6 p.m., Imperial Hotel, Birmingham. "Speech Communication Under Conditions of Deafness or Loud Noise," by Dr. W. G. Radley. *Mersey Centre:* Monday, March 1, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Ripple Control on High-Voltage Networks," by Messrs. T. W. Ross and R. M. A. Smith. *Radio Section:* Wednesday, March 3, 5.30 p.m., Victoria-embankment, W.C.2. "Testing of Communication-Type Radio Receivers," by Messrs. W. J. Bray and W. R. H. Lowry. *Institution:* Thursday, March 4, 5.30 p.m., Victoria-embankment, W.C.2. "Electrification of the Warsaw Railway Junction," by Mr. J. Podoski. *Measurements Section:* Friday, March 5, 5.30 p.m., Victoria-embankment, W.C.2. "Magnetic Apparatus for Bomb and Mine Location," by Mr. A. Butterworth. "Locators of Small Metallic Bodies Buried in the Ground," by Mr. B. Roston.

INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 2, 5.30 p.m., Great George-street, S.W.1. "First Stages in the Construction of the Jan Smuts Airfield, Johannesburg," by Messrs. W. R. Greathead and R. D. Hawkins. *South Wales Association:* Tuesday, March 2, 6 p.m., Institute of Engineers, Park-place, Cardiff. "Pumping Machinery," by Mr. H. R. Lupton. *North-Western Association:* Friday, March 5, 7 p.m., College of Technology, Manchester. Meeting with INSTITUTION OF STRUCTURAL ENGINEERS. "Masonry Construction," by Mr. E. G. Warland.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties Branch:* Tuesday, March 2, 6.30 p.m., Scientific and Technical Institute, Corporation-road, Middlesbrough. "Structural Engineering in Chemical Manufacture," by Mr. D. W. Portus.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Tuesday, March 2, 7 p.m., James Watt Institute, Birmingham. Repetition of Presidential Address, by Mr. R. A. Riddles. *Institution:* Friday, March 5, 6.30 p.m., 39, Victoria-street, S.W.1. "Flameproof Lighting and Power Installations," by Mr. S. L. Lyons.

SHEFFIELD METALLURGICAL ASSOCIATION.—Tuesday, March 2, 7 p.m., 198, West-street, Sheffield. "Early History of the Sheffield Iron and Steel Industry," by Mr. A. Allison.

ROYAL STATISTICAL SOCIETY.—*Industrial Applications Section:* Wednesday, March 3, 6.30 p.m., 95, New-street, Birmingham. "A Statistical Case Book," by Mr. A. Shaw. Friday, March 5, 6 p.m., 2, Savoy-hill, W.C.2. "Consumer Research in the Electricity Supply Industry," by Mr. W. Pridmore.

ROYAL SOCIETY.—Thursday, March 4, 4.30 p.m., Burlington House, Piccadilly, W.1. "Calculating Machines," by Mr. H. A. Newman, F.R.S.

INSTITUTE OF WELDING.—*South London Branch:* Thursday, March 4, 6.30 p.m., Institute of Marine Engineers, 85, The Minories, E.C.3. "Welded Pressure Vessels," by Mr. H. N. Pemberton.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 5, 6.15 p.m., Mining Institute, Newcastle-upon-Tyne. "Resistance to Buckling of Light-Alloy Plates," by Mr. W. Muckle. "Measurement of Water Movements Associated with Ships," by Dr. E. G. Richardson.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, March 5, 6.45 p.m., Engineers' Club, Manchester. "Modern Trends in Oil Refining," by Mr. E. J. Dunstan.

INSTITUTE OF ECONOMIC ENGINEERING.—*Midland Region:* Saturday, March 6, 2.30 p.m., 95, New-street, Birmingham. "Rubber and Its Manufacture," by Mr. D. R. Burrows.

REINFORCED-CONCRETE ROOFS FOR LOCOMOTIVE ROUND-HOUSES AND SHEDS.

(*For Description, see Page* 199.)

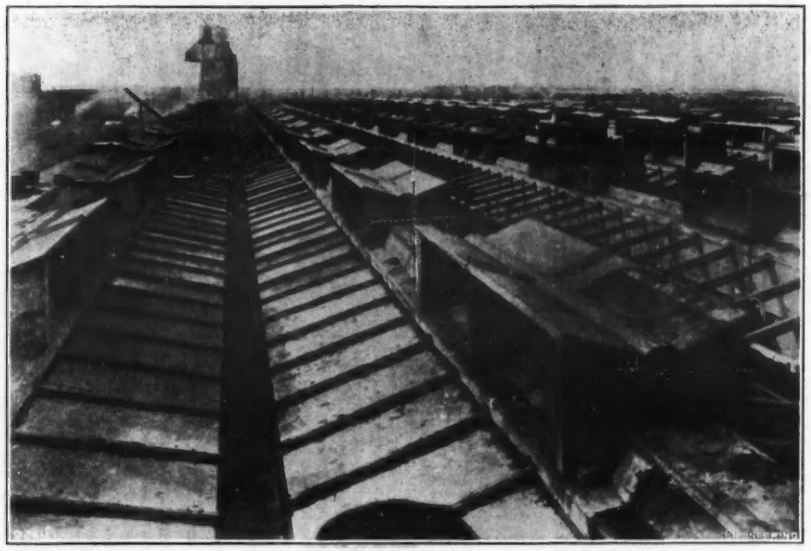


FIG. 8. REINFORCED-CONCRETE ROOF ON STRAIGHT SHED.

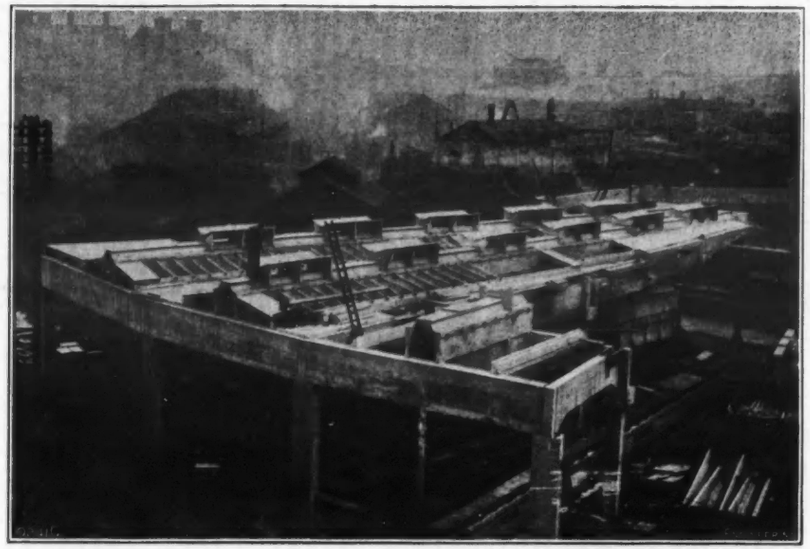


FIG. 9. ROUND-HOUSE IN COURSE OF ERECTION.

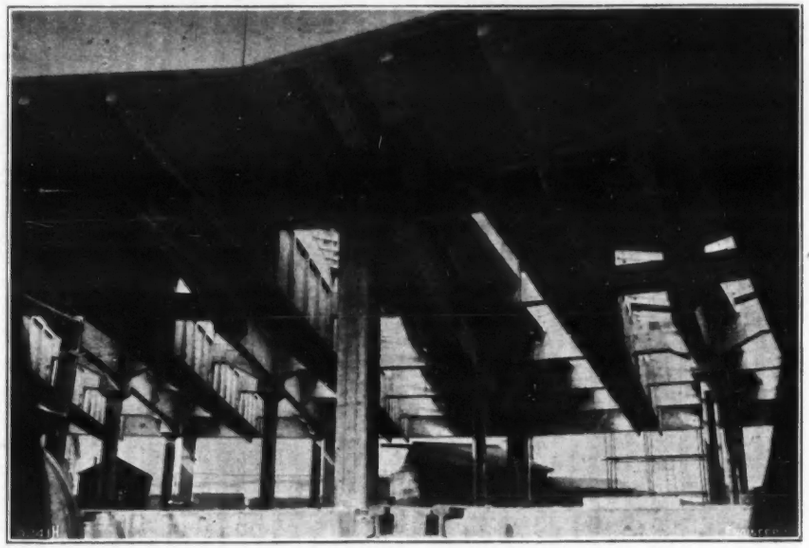


FIG. 10. UNDERSIDE OF PARTLY-CONSTRUCTED ROUND-HOUSE ROOF.

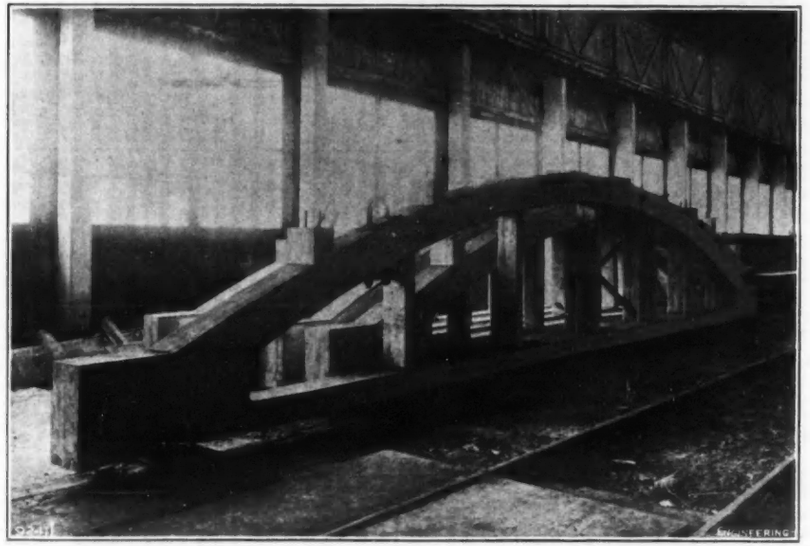


FIG. 11. REINFORCED-CONCRETE TIED ARCHES FOR TURNTABLE ROOF.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Wednesday.

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The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, FEBRUARY 27, 1948.

VOL. 165. No. 4283.

RESEARCH FOR INDUSTRY.

THE examples of misapplied science forced upon the unwilling attention of the British public during the war were not without effect in promoting an unprecedented degree of "research-mindedness," which has developed during the past two years into a widespread realisation of the extent to which industrial research may be able to further this country's economic recovery. Among those most intimately concerned with the organisation of applied science the view is commonly held, and has been frequently stated, that the proper use of scientific resources must be a significant, and may prove to be a deciding, factor in post-war prosperity. While the general tenor of such pronouncements will hardly be disputed, it is not merely legitimate but highly desirable to inquire whether British scientific resources are, in fact, adequate for a task of such critical importance, and whether they are being utilised as effectively as possible. Such questions are of especial urgency since, in the nature of things, the fruits of applied science take time to mature, whereas the national economy is in the balance at this present moment and needs that the whole power of industrial research should be brought to bear without delay.

Here is a task that calls not only for present planning, but for future vigilance as well; a task that demands organised effort by individual commercial undertakings within industries no less than by the co-operation of industries within the national economic structure; a task to which both scientist and business man must contribute foresight as well as knowledge. The advance of scientific applications and the growth of manufacturing production have been accelerated during the war in other countries than this, with the result that many of our pre-war markets have disappeared altogether because other nations are either making goods for themselves or have succumbed to competition dictated by reciprocal exchange of commodities beyond Britain's present capacity to export. Faced, in addition, with a buyers' rather than a sellers' market, it now becomes of greater importance than ever before for this country to make for export the products of those industries that exploit the results of the most recent and advanced scientific research.

It is significant of the trends of readily exploitable scientific research, and perhaps also of the mentality of those engaged in such research and in the industries which they serve, that all the commodities mentioned above, together with many others that come readily to mind, fall broadly within the scope of engineering and chemistry, where they represent relatively modern branches of constructive enterprise. The potential benefits of the commercial applications of scientific research, however, are far wider. They extend, for example, to industries of great antiquity like agriculture and building, in which the discreet replacement or modification of traditional methods, processes and materials by alternatives based on experimental research already enjoys a substantial and promising measure of success. Intelligently applied science, therefore, can revitalise old industries no less than promote new ones, and there is scope in each type for technical developments that will enhance the volume and value of British exports. Even among activities such as transport, civil engineering construction, communications, power supply and public services generally, which in the main are inherently unexportable, the improvements due to research react indirectly on the cost and marketing of most exports. Finally, it is worth noting the potentialities of employing scientific methods in the administration and organisation of industry, as distinct from its materials and products. Such operational research, as it has come to be called, offers a means of "doing properly what was previously done after a fashion," to quote Sir Edward Appleton, and should prove an increasingly attractive device in present circumstances.

It will be conceded, therefore, that very few, and none of the most profitable, activities of British industry lie outside the scope of scientific research. Up to a point, appropriate research services are available in the Government-sponsored establishments of the Department of Scientific and Industrial Research. The work done by these laboratories, and by many other State-aided research stations attached to Government departments, is universally appreciated for its high quality and steadily expanding scope. Quite properly, however, it is primarily concerned with basic problems of common interest or with types of investigation demanding very big and expensive equipment. There is always likely to be more than enough of such problems to absorb the attention of the staff, and to occupy the apparatus, of public research establishments, whose programmes, consequently, neither can nor should be comprehensive. Indeed, the day-to-day technical problems of commercial undertakings and the peculiar requirements of individual industries commonly demand an extensive background knowledge that belongs only to research workers who are in daily contact with the practical operation of the plant, the processes and the people they serve.

The present extent to which scientific and technical research is carried out by British industry within its own factories and laboratories therefore becomes a matter of sufficient public concern to justify a considerable statistical survey, such as was undertaken by the Industrial Research Secretariat of the Federation of British Industries about two years ago. The Federation's report* is a statistical summary and analysis of replies, to a questionnaire, received from 420 firms each expending at least 1,000*l.* per annum on research, and estimated to cover some 75 per cent. of British industry's total research activities. Most of the information relates to the year 1945 or the financial year 1945-6, so that some general increase may be assumed as regards subsequent expenditure, but no substantial change is likely to have occurred since that date in the figures for man-power, accommodation or equipment. On these assumptions, it appears that British industry is now spending over 30,000,000*l.* a year on research, which is carried out by 45,000 people, of whom about 10,000 are qualified scientists and engineers. Governmental expenditure upon, or in aid of, industrial research brings the total up to about 35,000,000*l.*—a tenfold increase during the past 15 years. Continuance of this significant rate of growth is promised by the fact that three firms out of every five who are doing research, plan considerable increases of laboratory buildings and qualified staff. The delays experienced, both in

* *Scientific and Technical Research in British Industry.* Published (July, 1947) by the Federation of British Industries, 21, Tothill-street, London, S.W.1. [Price 1*s.*]

putting these projects into effect and in the acquisition of scientific apparatus, have prompted the Federation to urge that such expansion schemes should be given higher priority.

Among many interesting matters revealed by the Federation's statistics is the prominent position of the engineering, and to a hardly less extent, of the chemical, industrial groups. While it is not possible to relate their research activities to factors fairly representative of the magnitude of these industries, it is clear that both are alive to its importance. Nearly half the qualified scientists in industry are chemists and one-third are engineers, but whereas, in industry as a whole, two other persons are employed with each qualified scientist, the figure for engineering of all types is three, and in automobile and aeronautical research 14 other persons are employed. Correspondingly, the average expenditure throughout industry is about 2,000*l.* per annum for each qualified scientist, but about 9,000*l.* in aeronautical and automobile research. The apparent conclusion, that the newer types of engineering have a clearer appreciation of research than the older ones, must be modified if the qualified, as contrasted with the total, research staffs are regarded as the criterion of progressive outlook and standard of work. While, therefore, the avowed intention of engineering firms to enlarge their research programmes is beyond reproach, it is satisfactory to note elsewhere in the report that the demand for qualified research engineers figures prominently among the additional staff required.

Notwithstanding the broad scope of the Federation of British Industries' inquiry, it is not easy to deduce from the information compiled whether the magnitude of the British research effort, in being or in prospect, is really adequate for the nation's industrial needs. The facts that no more than about 60 per cent. of the replies indicated the intention to expand research activities by firms whose wish to increase the size of their business may, perhaps, be assumed, and, secondly, that the Federation deem it necessary once again to stress the importance of every commercial undertaking having a scientific staff commensurate with its technical operations, both seem to suggest otherwise. This impression is supported by the Federation's emphasis on the need for greater effort by industrial research staffs, and the oft-repeated statement that no firm is too small to employ at least one individual to keep under review the potential applications to his firm's production of available scientific knowledge.

One further resource not mentioned in the report is the privately-owned laboratory. The number of these establishments in Britain is small, but they enjoy enviable reputations for accurate standard test work, development of prototype machines and pilot plant, and fairly straightforward experimental research of an immediately applicable character. Except for a few well-established test houses, these commercial research laboratories are relatively recent undertakings and their possible contributions to industry, as means of conducting researches or as manufacturers of experimental equipment, deserve to be more widely known and utilised. A recent publication* by the United States Department of Commerce reveals that this class of work figures prominently among the industrial research resources of the United States, and is regarded as being of comparable status to much of the purely commercial work undertaken for fees by college laboratories. This list contains well over 200 commercial laboratories, with a coded classification of the types of work that they undertake; and, even when allowance is made for the considerable proportion of simple commodity-testing included, there remains an impressive contribution to the progress of a wide range of technical industries. Whether at home or abroad, the value generally, and to the small firm especially, of being able to buy a piece of experimental research as and when required can readily be appreciated. It prompts the belief that there is scope for more private research companies, always provided that they are administered with scientific accuracy and integrity.

* *Directory of Commercial and College Laboratories.* National Bureau of Standards Miscellaneous Publication M.187. United States Government Printing Office, Washington, D.C. [Price 30 cents.]

TELEPHONE TRANSMISSION-RATING.

In the present era of controls, shortages and sellers' markets, it tends frequently to be forgotten that the true criterion of any service is that, as far as possible, it provides for users' requirements in the most efficient and economical way. This applies equally whether the service is in the form of goods, power or amenities; and whether the personal element is or is not a predominant factor. The resulting quality, however, must be a matter for compromise, since the attainment of maximum efficiency may not be possible on the grounds of expense. On the other hand, too great an insistence on economy may have the effect of driving away custom rather than attracting it. Indeed, a whole range of influences may be inherent in the problem, the effects of which, owing to the variety of their nature, cannot be combined into a formula simple enough to provide a solution which will be satisfactory either technically or economically. It is therefore necessary, as is so often the case, to forgo the ideal for the practicable.

An example of this, which is by no means without its complications, is provided by a paper on "A Survey of Telephone Transmission-Rating," which was read before the Institution of Electrical Engineers by Mr. L. C. Pocock on Thursday, February 5. The author is concerned with the part played by the quality of the transmission in providing a satisfactory telephone service; and with the methods of determining the numerical values of this service, which are known as "transmission-service" ratings. This determination involves the complementary idea of "impairment" in the quality of the service as well as the expression of the impairments of parts of the circuit in such a way that they can be combined to give that of the whole. It thus differs profoundly from the previous practice of planning telephone circuits to give a pre-determined overall attenuation or received loudness; and of assessing speech distortion and other factors solely on a qualitative basis. This practice, it is argued, is unsuited to modern requirements for three reasons. It is uneconomical to design circuits on a loudness basis alone, since to do so neither makes consistently for improved transmission, nor ensures that transmission of the required grade will be provided at minimum cost. It neglects subscribers' requirements; and the advantages which can be obtained by studying them. It does not take subscribers' behaviour into consideration, although this has been found to be an important factor in assessing circuit performance. That behaviour depends partly on the characteristics of the circuit. It is desirable, therefore, to eliminate as far as possible such characteristics as are unfavourable and to utilise those which are desirable.

To comply with these conditions the American Telephone and Telegraph Company, some years ago, devised a system of specifying each circuit in terms of certain parameters, and of utilising a measurable quantity which could be related to the impairment in transmission-quality experienced by the subscriber. The parameters required to describe the circuit under this system are its attenuation and the attenuations of the sidetone paths at the transmitting and receiving ends, as well as the efficiency of the receiving end for line noise and circuit distortion. It is also necessary to know the amounts of line and room noise. All these quantities can be defined so that they are mutually independent; and all are capable of measurement. Further, it has been found that the "repetition-rate," or the average number of times a subscriber finds it necessary to repeat a word or sentence in one unit interval, can be used as a criterion of circuit quality; and is, indeed, the best known method of assessing the relative performance of circuits in service. The relationship between repetition-rate and transmission impairments for all practical values of the circuit parameters can be expressed in decibels, so that the appropriate impairments of any combination of the selected parameters can be added together.

In spite of its scientific basis, the adoption of the transmission-rate system in countries other than the United States has been slow; and it was not in fact until 1938 that the Comité Consultatif International Téléphonique (which is usually known as C.C.I.F. to distinguish it from the corresponding telegraph committee) came to the conclusion that it afforded the best known measure of telephone performance. This delay was due partly to the fact that, as the system is essentially empirical, a great deal of work would have been necessary to collect the data; and much of this data would have become obsolete in the course of a few years as transmission improved. The necessary work of collection also would have had to be carried out independently in each country, a task which would have meant the installation, maintenance and supervision of a large number of sets with special controllable features and a very long series of repetition observations. Moreover, when the data had been collected, the results obtained under different conditions in different countries would have to have been co-ordinated in some way. In this connection it should be noted that one of the difficulties of obtaining repetition-rate data is the obligation not to infringe the privacy of subscribers' calls. It is therefore fortunate that the existence of two large bodies of employees at the Bell Laboratories and in the building of the American Telephone and Telegraph Company, with considerable tie-line traffic between them, enabled the latter concern to make observations under service conditions without tapping subscribers' lines.

To deal with this situation an attempt is now being made by the C.C.I.F. to employ articulation and received level as bases of a system of transmission-service rating. Under this system the circuit is rated by its performance under the worst conditions, instead of by its average performance for all subscribers. In can, in fact, be compared with the practice of inspecting a manufactured product on the basis of minimum requirements rather than by employing quality control methods to maintain a given standard of production. The application of this system involves the direct determination by articulation tests of the attenuation that must be added to each circuit, in order that the limiting percentage articulation may be ascertained; and the evaluation of the relative average subscriber's level at the transmitter. The first of these measurements can be made in the laboratory. For the second, the data have to be obtained in service, or by extensive laboratory tests, the object of which is to determine to what extent the talking level at the transmitter varies as a function of the side tone and to what degree it is a function of the ambient noise. This study is necessary in order that the results of the articulation tests, which are made at a constant talking level, may be corrected to take into account the variation in talking level which occurs in practice.

So far as the articulation tests are concerned, uniformity of comparisons can be secured by testing a typical circuit for each country. The determination of talking level in service would, however, have to be done in each country separately, so that a great deal of work will be necessary before a common basis can be laid down. When each country has a circuit with a known articulation equivalent, the performance ratings of the different kinds of set and the different local lines can be determined by comparison with the calibrated circuit. This system, it should be noted, is not related to the repetition-rate; and as yet the data available are inadequate to show whether it is completely equivalent in value to that method. It is believed, however, that it will give more reliable and useful results than the old method of rating by loudness or volume.

As a result of his analysis, Mr. Pocock reaches the conclusion that on commercial grounds the design of circuits should be determined by their performance in service and should be based on the average performance in that service. If these postulates are accepted, he argues that the only available criterion of performance is the repetition-rate with all its disadvantages and complications, and that no method should be accepted until it gives the same results as that method. On the other hand, it should be possible to establish a rating method, based on laboratory tests and subscribers' behaviour, which will give ratings that agree with repetition-rate ratings. To determine whether that is so, more repetition-rate data must be collected.

NOTES.

THE INSTITUTION OF MECHANICAL ENGINEERS.

OWING to the fact that only corporate members of the Institution of Mechanical Engineers will be entitled to attend the annual general meeting on March 19, 1948, the presentation of prizes was arranged for the general meeting which took place on Friday, February 20, when nominations for the Council were also made. Lord Dudley Gordon, D.S.O., the President, was in the chair while this business was conducted; after which he vacated it to Mr. Percy Good, C.B.E., President of the Institution of Electrical Engineers, and a joint meeting of the two Institutions discussed a paper on "Corrosion of Heating Surfaces in Boiler Plants," by Mr. J. R. Rylands, M.Sc., and Mr. J. R. Jenkinson, B.Met. The Council nominations were, as President, Major Wlliam Gregson, M.Sc.; vice-presidents, Dr. H. J. Gough, C.B., M.B.E., F.R.S., and Mr. A. Roebuck; ordinary members of Council, Dr. D. S. Anderson, B.Sc.; Dr. R. W. Bailey, Wh.Sc.; Wing-Commander T. R. Cave-Browne-Cave, C.B.E., R.A.F.; Vice-Admiral (E) D. C. Ford, C.B., C.B.E.; Air Vice-Marshal R. O. Jones, C.B., A.F.C., B.A.; Dr. H. E. Merritt, M.B.E.; Mr. B. W. Pendred; Major-General W. S. Tope, C.B., C.B.E.; the Hon. J. K. Weir, C.B.E., M.A.; Dr. W. Ker Wilson, Wh.Ex.; Professor E. G. M'Ewen, B.Sc. (Eng.) (associate member); and Mr. D. Rebbeck, M.A., M.Sc. (associate member). In addition to the foregoing, Mr. W. O. Skeat (associate member) was proposed by Mr. Arthur Arnold. The Council prizes for the year were then presented by the President, the recipients being: the Thomas Hawksley Gold Medal to Mr. H. Hillier, O.B.E., for his paper on "Feed Distribution and Hunting in Marine Water-Tube Boilers"; the George Stephenson Prize to Mr. E. L. Diamond, M.Sc. (Eng.), for his paper on "The Development of Locomotive Power at Speed"; the Dugald Clerk Prize to Mr. A. J. R. Lysholm, for his paper on "A Contribution to the Solution of the Gas-Turbine Problem"; the Water Arbitration Prize to Mr. J. A. Sumner, for his paper on "The Norwich Heat Pump." Starley Premiums were awarded to Mr. S. Markland, O.B.E., and Mr. N. Tattersall, for their paper on "Some Notes on the Design, Development and Production of High-Speed Compression-Ignition Engines"; the Herbert Akroyd Stuart Prize to Mr. H. O. Farmer, M.C., B.Sc., for his paper on "Free-Piston Compressor Engines"; Thomas Lowe Gray Prizes to Mr. A. Sykes, B.Sc. (Eng.), Wh.Ex., for his paper on "Progress in Turbine Gear Manufacture in Recent Years," and to Mr. C. Timms, M.Eng., for his paper on "The Measurement of Errors in Gears for Turbine Reduction Drives"; the T. Bernard Hall Prize to Mr. H. Birchall, B.Sc. Tech., and Mr. G. F. Lake, M.A., for their paper on "An Alternative Form of Pressure Vessel of Novel Laminar Construction"; the Joseph Whitworth Prize to Mr. F. F. P. Bisacre, O.B.E., M.A., B.Sc., and Mr. G. H. Bisacre, M.A., for their paper on "The Life of Carbide-Tipped Turning Tools"; Institution Prizes to Mr. E. Mensforth, C.B.E., M.A., for his paper on "Airframe Production"; to Professor A. Porter, M.Sc., Ph.D., for his paper on "Basic Principles of Automatic Control Systems"; to Dr. D. M. Smith, for his paper on "The Development of an Axial-Flow Gas Turbine for Jet Propulsion"; and to Mr. K. W. Todd, M.Eng., for his paper on "Practical Aspects of Cascade Wind Tunnel Research." Graduate Prizes, were awarded to Mr. Z. M. Rogowsky, B.Sc. (Eng.); Mr. J. Humphries, B.Sc.; Mr. T. L. Gardner, B.Sc.; Mr. T. M. Charlton, B.Sc. (Eng.); and Mr. J. L. Wilson, B.Sc.; and the Hele-Shaw Medal and National Certificate Prize to Mr. F. V. Hopkins. The James Clayton Prize of 1,300*l.* was divided equally, and awarded to Mr. T. E. Beacham, B.Sc. (Eng.) (Lond.), for his contribution to the development of the variable-pitch propeller, high-speed hydraulic pumps, and other hydraulic devices, by way of research, invention and design, communicated in part to the Institution during 1947; and to Mr. J. E. Sears, C.B.E., M.A., for services to engineering science and manufacture by researches and developments in metrology and gauging, some of which were described in a lecture, given during 1947.

RESTRICTIONS ON ELECTRICAL DEVELOPMENT.

In order to ensure that the reductions in the peak industrial load, which will be necessary during the next few winters, shall not be neutralised by demands for electricity from non-industrial consumers, the Minister of Fuel and Power, through the Electricity Commissioners, has circularised the supply undertakings asking them to impose certain restrictions on this class of consumer. In particular, it is requested that new services and apparatus (especially on hire or hire purchase) should be provided only for essential public services; new domestic or commercial premises; existing houses, which have sustained war damage or have been divided; farms and farm-workers' cottages, where this will assist increased food production; existing premises where present facilities for heating and/or cooking are worn out or where serious hardship would result if a supply were not provided, and where a medical certificate is produced justifying supply on the grounds of health. It is also suggested that where electric cookers and water heaters, other than wash boilers or kettles, with a load of 2 kW or more are installed in new houses or flats; or where either is installed in a house in which the other already exists, a change-over switch should be provided, if practicable, to prevent the simultaneous use of both appliances. New or additional supplies for space heating in existing premises should be discouraged and supplies for cooking should be provided only where no reasonable alternative exists. In this connection, the Electricity Commissioners have been informed that the possibility of restricting still further the production of consumers' apparatus has been examined. It has been found, however, that the production of electric fires for the home market has been reduced already to 5 per cent. of the industry's capacity, and that any further restriction would, therefore, prove ineffective. It is also considered that it would be too difficult to operate a licensing scheme for the sale of electric fires. Similarly, the manufacture of electric water heaters for the home market has already been severely restricted to limits consonant with the new housing programme. It will, be retained at this level therefore, for the present. It is understood that the whole position will be reviewed again in the summer, but considering the large number of exceptions it is open to doubt whether the suggested scheme will be very effective.

WORLD MERCHANT SHIPBUILDING, 1947.

During 1947 there were launched, in Great Britain and Northern Ireland, 393 merchant ships, aggregating 1,202,024 tons, or 56·9 per cent. of the output of the world for that year, which was 2,111,886 tons. It is pointed out in the *Annual Summary of the Mercantile Shipbuilding of the World for the Year* 1947, published by Lloyd's Register of Shipping, 71, Fenchurch-street, London, E.C.3, that the tonnage launched in the shipyards of the United Kingdom represented 53·3 per cent. of the world's output in 1946, 34·0 per cent. in 1938, and 58 per cent. in 1913. The *Summary*, which contains statistics regarding the merchant ships of 100 tons gross and upwards, launched in 1947, whether they were completed during the year or are still under construction, states, however, that, since 1914, complete returns from Russia have been available only for the years 1926 to 1929, and that, for 1937 and 1938, the statistics concerning Spain may not be complete. Again, since June, 1939, returns are not available respecting Danzig, Germany, Hungary, Japan or Poland, and for the period 1939 to 1945 statistics relating to Belgium, Denmark, Finland, France, Holland, Italy and Norway are limited practically to the first quarter of 1940. The 1947 total of 1,202,024 tons for Great Britain compares with 1,133,245 tons for 1946, 1,030,375 tons for 1938, and 1,185,000 tons representing the average annual launchings for the eight years 1923 to 1930. The shipping launched in overseas countries during 1947 comprised 444 merchant vessels, aggregating 909,862 tons, a net decrease of 84,314 tons, or 8·5 per cent., from the 1946 total. Actually, however, there were considerable increases in the launchings of Sweden, France, Holland and Denmark, but these were counterbalanced by decreases in other countries, the largest being 336,446 tons in the United States, the output of that country for 1947 being only 164,848 tons. Some interesting facts may be gathered from the *Summary* concerning special types of vessels and machinery included in the output for the year under review. The world total of the steamers launched, namely, 257 vessels, aggregating 934,037 tons, includes one ship, of 12,200 tons, to be fitted with turbo-electric drive; 61 vessels, making together 524,075 tons, to be fitted with steam turbines; and 25 vessels, comprising 95,589 tons, having a combination of steam reciprocating engines and turbines. Of the total of the steamships launched in the world, an aggregate of about 850,000 tons represent steamers fired with oil fuel, while 530 vessels, totalling 1,168,584 tons, have been launched in which internal-combustion propelling machinery is to be employed. Eight of these ships, making together 15,644 tons, are to be fitted with electric drive.

ELECTRICITY SUPPLY IN NORTHERN IRELAND.

Under a Bill which was published by the Government of Northern Ireland on Tuesday, February 17, 1948, it is proposed to establish a Joint Electricity Committee, the main functions of which will be the control of electrical generation and primary transmission, and the purchase, at the cost of production, of all the electricity produced in the country. It is also proposed that the Committee should have power to re-sell current to the distributing authorities at a standard tariff, which will include the incidental expenses incurred by the central body. In addition, it will be empowered to prepare schemes designed to ensure the maximum efficiency and economy in the installation of new plant and the production of energy from all sources. This measure, therefore, bears a distant likeness to the Electricity Supply Act, 1926, under which the Central Electricity Board was established to perform somewhat similar duties. The new Joint Electricity Committee is apparently imposed on the existing Electricity Board, to which latter body the generating stations and undertakings constructed and acquired by the Ministry of Commerce under emergency legislation will be transferred. The Board is to be expanded to deal with its increased responsibilities. The Bill also provides for the institution of a system of loans for the purchase of agricultural electrical equipment, and for the setting up of a Rural Electrification Council to encourage the use of electricity in agriculture.

SUMMER SCHOOL IN PHYSICS.

A four-days course in theoretical physics, dealing particularly with creep in metals, similar in conception to the course on the electrical properties of solids held in June, 1946, and to that on mechanical properties of metals, held in July, 1947, is being arranged to take place in the H. H. Wills Physical Laboratory of the University of Bristol, from June 2 to 5. The summer school, as the course is called, is intended mainly for members of the staffs of Government and industrial laboratories who wish to acquire knowledge regarding the theoretical side of subjects with which they have been concerned from the experimental standpoint. Lectures will be given by Professor N. F. Mott, F.R.S., and other members of the staff of the Wills Physical Laboratory. In addition to the regular lectures, there will be opportunities for research workers attending the course to discuss their own work and its theoretical implications. Much of the course will deal with developments which have taken place since the 1947 summer school, though it is emphasised that it will not be assumed that students attending this course were present last year. Some familiarity with the concept of dislocations, as explaining slip, however, will be advisable. The subjects to be treated will include slip at grain boundaries and its effects; grain growth, recrystallisation and the theory of grain-boundary slip; the geometry of dislocation and the theory of slip bands; the theory of transient creep; slip in solid solutions; the diffusion of carbon in iron and the elastic after effect; the influence of carbon on the mechanical properties of iron; the mechanisms of internal damping; and crystal growth and the origin of dislocations. The fee for the course is five guineas and the number attending will be limited to about 50. Further particulars

and forms of application, to be returned by April 15, can be obtained either from the director of the Department of Adult Education, The University, Bristol, or from the secretary of the Institute of Physics, 47, Belgrave-square, London, S.W.1. The University of Bristol, in co-operation with the Institute of Physics, also announces that a second summer school in the physics of solids (experimental and theoretical) will be held at Bristol from September 8 to 15, the subject being "The Oxides of Ionic Crystals." Further particulars of this second course will be announced in due course.

Co-operation in Electrical Laboratory Practice.

A scheme for the circulation of information on laboratory practice in electrical engineering has been inaugurated by the Governing Body of the Municipal College of Technology, Manchester. The scheme is intended to make available to other teachers and colleges details of new or improved laboratory experiments and methods developed by individual teachers and colleges, thus widening the circulation of results and facilitating the interchange of information. In this connection it is pointed out that the time taken to develop a good experiment is considerable and the pressure of other duties often prevents a teacher from developing more than one or two such experiments in the course of a year. It is proposed to issue, several times a year, a bulletin in which will be given a brief summary and index of laboratory experiments and methods submitted by individual teachers. Each piece of work will bear the name of the teacher concerned and the college with which he is associated. At the same time the teacher concerned will be asked to submit a detailed description and constructional drawings, together with any additional information which he thinks desirable, such as an account of the theory involved, a specimen laboratory instruction sheet or relevant references to published articles. This information will be filed and made available, on loan, to any teacher interested. In order to meet the possibility of several colleges asking for a given description, the promoters of the scheme request that four copies be submitted. For the present, at all events, the application of the scheme is to be restricted to the electrical-engineering laboratory work of Higher National Certificate and Degree standard; hence, at this stage, only the co-operation of colleges dealing with such work is asked for. The organiser of the scheme, to whom all correspondence should be addressed, is Dr. E. Bradshaw, M.Sc.Tech., M.I.E.E., of the Electrical Engineering Department, College of Technology, Manchester, 1.

The Royal Aircraft Establishment Technical College.

The founding of the Royal Aircraft Establishment Technical College is a further step towards the provision of education and training for those who wish to enter and make their career in the aircraft industry, particularly in the field of research and development. The importance of aeronautics to this country, and of training facilities for its understanding and development, were emphasised by the Chancellor of the Exchequer, Sir Stafford Cripps, when he formally opened the college at Farnborough, Hants, on Wednesday, February 18. A full appreciation of the performance and design of aircraft requires a knowledge of the basic principles of many branches of engineering science; familiarity is required with the theories of aerodynamics, structures, and heat engines, while, from the standpoint of accessory equipment, knowledge is also required of the principles of hydraulic, electrical and radio engineering. Although the aircraft industry is still young, these subjects have already become matters for specialist study and development, mainly because of war-time stimulus. Training schemes should therefore encourage and enable students to acquire a broad technical background before specialising. This was recognised by the Royal Aircraft Establishment, which, as early as 1918, designed an educational scheme to give promising apprentices an opportunity for studying the principles of the sciences underlying aircraft engineering. During the war, it was considered that a special teaching establishment should be associated with a body covering such a wide range of activities as the R.A.E. Accordingly, a staff of lecturers was built up, and they collaborated with the senior staff of the R.A.E. in framing a curriculum for the students selected to attend the new college. The present scheme caters only for the junior grades of R.A.E. employees, but, as well as providing courses for students in grades such as scientific assistant, engineering or craft apprentice, it also provides training for drawing-office tracers and junior clerks. Students are normally admitted to the college between the ages of 16 and 18 years, entrance being by competitive examination or interview, and sometimes both. The course for scientific assistants and apprentices lasts for periods up to five years, this time being divided between attendance at the college, and work in the R.A.E. These classes of student are expected to obtain the R.A.E. Diploma, the London University External Degree in Engineering, or the Higher National Certificate in Mechanical and Production Engineering, according to the studies and training chosen. The curriculum also includes non-vocational subjects, the purpose of which is to help to broaden the students' interests, and to foster a sense of citizenship. Throughout the training period wages are paid to all apprentices, and a subsistence allowance is made to those living away from home, for whom the R.A.E. hostel is available. The college is housed in a former convent adjacent to the R.A.E., and is being suitably adapted and equipped. The principal of the college is Mr. R. P. Peggs, M.A., M.I.Mech.E.

LETTER TO THE EDITOR.

PROFESSIONAL SALARIES.

To the Editor of Engineering.

SIR,—The correspondence on page 160, *ante*, of your issue of February 13, on the subject of the engineering "Charter" published by the Association of Scientific Workers, missed an important point to which I would like to draw attention. It will have been noticed by those of your readers who have seen a copy of the "Charter" that, with the exception of the Assistant grade, the scales have not been formulated on a "rate for age" basis. This was done deliberately in order to avoid (as Mr. Gough puts it) "equating the genius with the moron," and it will be clear that the scheme, by providing for promotion at an early age for the more able engineers and metallurgists, does nothing to stifle initiative. On the contrary, the carefully considered range of salaries put forward for the various grades is meant to provide prospects which will compare with equivalent professional employment outside the engineering and metallurgical industries.

It has been interesting to note that, among the many requests for copies of the "Charter," which the Association has received, there have been quite a number from engineering employers, which would seem to indicate that, on both sides of industry, there is a keen interest in this effort to remedy the present chaotic position. It is worth pointing out that it is because the A.Sc.W. organises engineers and metallurgists, in addition to scientific workers in other fields of employment, that it is able to make the authoritative comparisons which are the basis of the proposals published in the "Charter." The engineering membership is, moreover, by far the largest section of the total membership of the A.Sc.W., and covers most branches of the engineering industry. It must be clear, too, that, although the Association is not the only body showing concern over the prospects of the scientist and engineer in industry, it is alone in being suitably constituted to take positive action to achieve its policy. The speed with which results can be achieved depends upon the weight of support received from the professional workers concerned.

Yours faithfully,

C. T. WILSHAW, A.I.M.
Chairman, Engineering and Metallurgical Committee, Association of Scientific Workers.

15, Half Moon-street,
London, W.1.
February 18, 1948.

BRITTLE FRACTURE IN MILD-STEEL PLATES—II.

(*Continued from page* 78.)

We continue below our report of the Conference on Brittle Fracture in Mild-Steel Plates, held at Cambridge on October 26, 1945, by reprinting the contribution of Mr. W. Barr, of Messrs. Colvilles, Limited, on "Brittle Fracture of American Ship Plates."

Brittle Failure of American Ship Plates.

Mr. Barr said that, arising out of the failure of certain American ships of welded construction, due to the occurrence in the plates of brittle fractures of a catastrophic nature, various consignments of plate samples were submitted for examination from time to time. Altogether, four separate consignments—A, B, C and D—were received, all of which were marked for identification with the name of the ship concerned, as shown in Table I, opposite. The plates varied in thickness between 0·70 in. and 0·90 in., with the exception of one plate at 0·50 in. The best example of brittle fracture was provided by consignment A, a photograph of which is reproduced in Fig. 31, opposite. Most of the other samples were so badly corroded that it was difficult to say what had happened, some of the fractures being associated with weld deposits, while others might quite well have been corrosion cracks. The best that could be done in the circumstances was to carry out a general metallurgical examination of the material, including chemical analysis, micro-examination, and determination of mechanical properties, the results of which are dealt with in sequence below.

The results for each plate are given in Table I. On the whole, the steel is typical of basic open-hearth of a high degree of purity. The very low content of residual alloys, nickel, chromium and molybdenum, indicates low scrap charges. The plates cover a wide range of carbon and manganese content. In the case of plates Nos. A1, D3 and D5, the carbon content is too high; indeed, Plate No. A1 is on the border line for safe welding. Plates D1 and D2 are dead-soft steel of the rimming type. A feature of the analysis is the nitrogen content, which is somewhat higher than is usual in basic open-hearth steel, the average for the United States being 0·004 to 0·005 per cent. It is not suggested, however, that the nitrogen content of these American plates is high enough to cause trouble. Plates A1 and A2 are illustrated in Fig. 31 and Plate D5 in Fig. 32, opposite.

The average structure of the plates, with one exception (Plate No. A1) was quite normal for plates of these thicknesses, rolled in modern fast-working mills, Fig. 33, opposite, being a representative example. Plate A1, on the other hand, had a decidedly coarser structure (see Fig. 34, opposite) for which the high carbon content is no doubt responsible. McQuaid-Ehn grain-size tests showed that the steel in every case was of the coarser-grain type (A.S.T.M. No. 2/4), which is normal for steel of ship-plate quality.

Where possible, length and cross tensile and Izod tests were taken from each sample; the results of these are given in Table II, opposite. In every case, except Plate No. D3, the maximum stress values agree with the analysis of the steel. In the case of D3, the abnormally low value appears to be due to the plate having been cooled very slowly. On normalising, the maximum stress was increased to 28·5 tons per square inch, which is normal for the analysis. As is to be expected from the analysis of the various plates, the maximum stress values cover a wide range compared with that recognised for ship plates in the United States, namely, 26 to 32 tons and 28 to 33 tons per square inch.

In regard to toughness as determined by the Izod impact test, it will be observed that the plates in the first consignment, A1 and A2, gave very low values. In the case of A1, the high tensile strength and coarse structure provide the explanation. In the other plate, A2, which has a normal structure, the low Izod is probably due to ageing, which may have been more or less local in its effect. Further Izod tests, carried out on this plate after heating to

BRITTLE FAILURE OF SHIP PLATES.

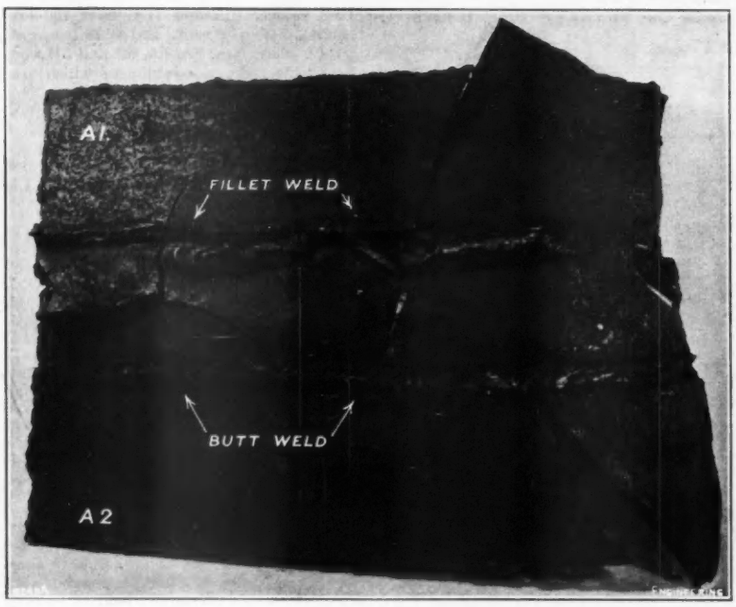


FIG. 31. PLATES A1 AND A2; S.S. "JOHN MARSHALL."

FIG. 32. PLATE D5; S.S. "SAM SOARING."

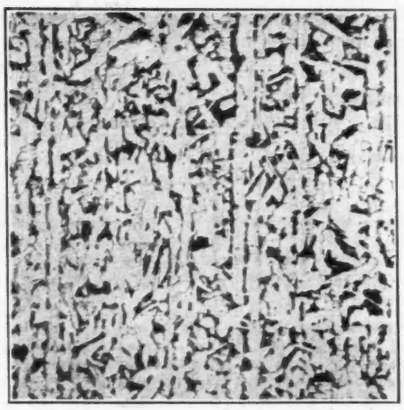


FIG. 33. PLATE A2. × 50.

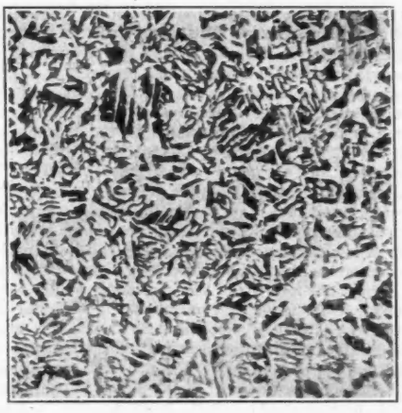


FIG. 34. PLATE A1. × 50.

TABLE I.—CHEMICAL ANALYSES, PER CENT.

Plate No.	Ship.	C.	Si.	S.	P.	Mn.	Ni.	Cr.	Mo.	N.	Thickness, In.
A1	S.S. John Marshall	0·285	0·05	0·020	0·013	0·49	0·02	0·03	0·01	0·007	0·70
A2		0·175	0·04	0·028	0·011	0·42	0·03	0·025	0·015	0·009	0·70
B1	S.S. John Fenimore Cooper ..	0·215	0·04	0·020	0·011	0·57	—	—	—	—	—
B2		0·235	0·03	0·027	0·010	0·50	—	—	—	—	—
C1	S.S. Theodore Sedgewick ..	0·215	0·17	0·022	0·010	0·49	—	—	—	—	0·75
D1	S.S. Sam Soaring	0·05	Tr.	0·029	0·012	0·28	—	0·02	0·015	0·005	0·89
D2		0·05	Tr.	0·029	0·012	0·28	—	0·03	0·015	0·005	0·89
D3		0·265	0·03	0·034	0·010	0·37	—	—	—	0·006	0·90
D4		0·20	0·02	0·030	0·010	0·42	—	—	—	0·007	0·70
D5		0·26	0·07	0·025	0·013	0·38	—	—	—	0·009	0·50

TABLE II.—MECHANICAL PROPERTIES (AS RECEIVED).

Plate No.	Maximum Stress, Tons per sq. in.	Yield Point, Tons per sq. in.	Elongation, Per cent.		Reduction of Area, Per cent.	Izod, Ft.-Lb.
			On 8 in.	$4\sqrt{\text{Area}}$.		
A1	34·1	20·4	21·5	—	39·9	8, 6, 3
A2	28·9	18·3	18·0*	—	50·9	6, 5, 3 5, 6, 23
B1	(Brinell Hardness = 122)		—	—	—	20, 6, 20 24, 22, 78†
B2	(Brinell Hardness = 125)		—	—	—	25, 16, 14
C1	L. 28·3	18·0	—	39·0	55·0	31,†20, 25
C1	X. 27·8	15·7	—	31·5	49·0	69, 31, 44
D1	L. 20·3	14·6	—	52·0	74·0	65, 54, 74
D1	X. 20·4	13·4	—	48·0	62·2	35, 33, 37
D2	L. 21·2	15·4	—	38·0	58·1	73, 71, 72
D2	X. 20·8	15·1	—	42·0	65·5	56, 40, 40
D3	L. 24·8	13·7	—	40·0	74·8	19, 17, 10
D3	X. 25·7	13·8	—	39·0	58·0	16, 15, 16
D4	L. 28·0	18·9	—	38·0	59·0	30, 25, 29
D4	X. 28·8	19·9	—	34·0	58·5	16, 13, 18
D5	L. 31·4	19·8	—	35·0	58·0	46, 34, 30
D5	X. 32·0	20·0	—	31·0	54·0	17, 17, 18

* Broke in pop marks. † Laminated.

500 deg. C. for one hour, gave values of 24, 21 and 21 ft.-lb., thus confirming the view that excessive brittleness was due to strain ageing. After normalising, the plates gave the following Izod values, which are quite normal:—Plate No. A1, 46, 34 and 44 ft.-lb. (length test), 50 per cent. crystalline; and Plate No. A2, 48, 55 and 70 ft.-lb. (length test), 50 per cent. crystalline. In the "as-rolled" condition, the Izod fracture of all the plates was 90 to 100 per cent. crystalline.

It will be appreciated that, owing to the nature of the plate specimens submitted, the location of test pieces was not open to much choice; consequently, the results of the mechanical tests given in Table II do not take into account possible local irregularities due to effects of cold work, ageing, etc. In view, however, of the evidence of strain-age embrittlement found in Plate No. A2, a more detailed study was made of Plate No. D5, which was evidently cut from a plate which had undergone considerable bending to shape (see Fig. 32). The Izod tests of this plate had been taken at a position remote from the fractured edge where there was least distortion. In this case, it was possible to obtain an additional Izod test immediately adjacent to, and in line with, the fractured edge shown in Fig. 32. The results obtained were only 6 ft.-lb., which compares with 17 ft.-lb. for the test in the same direction remote from fracture. This reduction of the Izod value from 17 to 6 ft.-lb. is accompanied by an increase in the Brinell hardness from 130 to 170. Thus, there is no doubt that this plate in the vicinity of the fracture is in an excessively brittle condition due to strain-ageing. It should be noted that, in the Izod tests recorded in Table II, the centre notch, in each case, was cut perpendicular to the plate surfaces, the other two notches being parallel

to the plate surfaces. In this and subsequent tables, L denotes a length Izod test and X a cross test.

From a consideration of the foregoing tests, the factor of practical significance is the evidence of excessive notch brittleness in three of the specimens. High carbon combined with coarse structure confuses the issue in one of the specimens, but the important aspect is the strain ageing, which has been so clearly established in one of the plates. While most of the other specimens gave Izod values which are more or less normal for ship plates of the thicknesses involved, the probability is that, in a systematic investigation of plates which have failed in a catastrophic manner, similar evidence of excessive notch brittleness due to strain ageing would be forthcoming. Moreover, there are sound grounds for believing that such brittleness will be a much more serious factor in a welded than in a riveted ship.

In regard to two of the specimens which were shown to be made of rimming steel, it should be pointed out that, in spite of the exceptionally high Izod value obtained on these plates, the fractures of the test pieces were nearly 100 per cent. crystalline. The extreme softness of these plates is combined with high ductility, which tends to give a false impression of the notch sensitivity as measured by the Izod test, since the major portion of the energy is absorbed in widening the notch by bending, thus reducing the stress concentration. Further, a feature of steels of this type is their susceptibility to strain ageing. In view of the wide variation in the steels represented by the specimens examined, it was decided to examine further American plates of comparable thickness which were available in the United States and to compare them with British plates of the same thickness, with particular reference to notch toughness.

For the purpose of this investigation, a batch of eleven American ship plates, ¾ in. and 1 in. thick, was obtained from stocks available in this country in the as-rolled state as delivered from the steelworks, the steel-making process involved in their manufacture being unknown. At the same time, representative samples of nine British ship plates of the same thicknesses were obtained for comparison. The British plates were all made by the basic open-hearth process.

The analysis of the plates is given in Table III, on this page, from which it will be observed that, in five of the American plates, the manganese content is decidedly lower than is customary in British practice. It would appear in these instances that the Americans have been substituting carbon for manganese, which may, of course, have been a war-time measure necessitated by a shortage of ferro-manganese. There is the same tendency towards higher nitrogen which was observed in the plates previously examined. Apart from this, the purity of the American steel compares favourably with the British, the phosphorus being very low. The residual copper content is also lower in the American steel.

It was not considered necessary to take tensile tests from all these plates, Brinell hardness tests being substituted. In each case, however, length and cross Izod impact tests were taken and the results of these are given in Table IV, on this page. In all these and subsequent tests, the notches were cut perpendicular to the plate surface so as to avoid discrepancies due to possible laminations in the plates. Comparison of average values for British and American plates of similar thickness shows the superiority of the former, particularly at ¾ in. The ¾ in. American plates showed an average Izod value of 18 ft.-lb.; ¾ in. British plates, 27 ft.-lb.; 1 in. American plates, 14 ft.-lb., and 1 in. British plates, 16 ft.-lb.

It will be observed that the lowest Izod values are obtained in the American plates with manganese content below 0·40 in., also that, for both steels, there is a decrease in Izod value with increased plate thickness. The two American plates with very low Izod values, 10A and 11A, have the lowest manganese, 0·30 per cent. and 0·28 per cent., respectively. Plate Nos. 2A, 4A, 6A and 5B were selected for tensile tests, the results of which are given in Table V. The results are normal.

(To be continued.)

TABLE III.—ANALYSES (PER CENT).

Plate No.	C.	Si.	S.	P.	Mn.	Ni.	Cr.	Mo.	Cu.	N_2.	Thickness, In.
American											
1A	0·22	0·03	0·030	0·010	0·36	0·02	0·03	0·045	0·030	0·006	¾
2A	0·215	0·04	0·025	0·010	0·34	0·02	0·02	0·035	0·025	0·006	,,
3A	0·27	0·03	0·030	0·010	0·31	0·16	0·05	0·045	0·025	0·007	,,
4A	0·18	0·04	0·020	0·013	0·415	0·06	0·05	0·030	0·145	0·007	,,
5A	0·225	0·02	0·029	0·014	0·47	0·15	0·11	0·035	0·105	0·004	,,
6A	0·205	0·05	0·038	0·016	0·41	0·02	0·05	0·025	0·025	0·008	,,
7A	0·23	0·04	0·037	0·010	0·48	0·02	0·02	0·025	0·020	0·006	1
8A	0·195	Tr.	0·014	0·008	0·40	0·12	0·04	0·010	0·16	0·004	1
9A	0·205	0·01	0·015	0·009	0·41	0·09	0·04	0·010	0·165	0·007	1
10A	0·28	0·08	0·030	0·019	0·30	0·03	0·05	0·010	0·045	0·008	1
11A	0·315	0·08	0·034	0·012	0·28	0·03	0·04	0·010	0·025	0·006	1
British											
1B	0·21	0·03	0·031	0·031	0·57	0·13	0·05	0·02	0·125	0·006	¾
2B	0·165	0·05	0·033	0·014	0·50	0·12	0·07	0·015	0·14	0·005	,,
3B	0·185	0·05	0·045	0·031	0·53	0·11	0·06	0·03	0·145	0·005	,,
4B	0·20	0·055	0·050	0·023	0·62	0·15	0·12	0·01	0·285	0·005	,,
5B	0·195	0·05	0·029	0·020	0·61	0·18	0·03	Nil	0·195	0·005	,,
6B	0·17	0·055	0·029	0·031	0·56	0·13	0·11	0·01	0·15	0·006	1
7B	0·19	0·055	0·039	0·030	0·59	0·13	0·07	0·03	0·14	0·006	1
8B	0·17	0·045	0·030	0·017	0·52	0·11	0·07	0·03	0·135	0·004	1
9B	0·165	0·04	0·055	0·016	0·68	0·13	0·15	0·01	0·105	0·005	1

TABLE IV.—*Impact Properties and Brinell Hardness of American and British Ship Plates, as Rolled.*

Plate No.	Brinell No. 1,000-kg. Load.	Izod Impact, ft.-lb.	Fracture, per cent. crystalline.	Thickness, in.
American				
1A	126	L. 14, 15, 13 Mean = 11 X. 7, 7, 8	100	¾
2A	128	L. 19, 22, 17 Mean = 15 X. 12, 11, 10	90	¾
3A	131	L. 19, 21, 19 Mean = 16 X. 14, 12, 12	90	¾
4A	121	L. 32, 34, 31 Mean = 30 X. 30, 22, 29	80	¾
5A	126	L. 22, 19, 22 Mean = 15 X. 8, 9, 11	90	¾
6A	118	L. 25, 28, 32 Mean = 24 X. 21, 18, 19	75	¾
7A	137	L. 10, 18, 15 Mean = 14 X. 16, 14, 13	90	1
8A	121	L. 30, 22, 24 Mean = 18 X. 13, 10, 10	90	1
9A	126	L. 25, 22, 25 Mean = 22 X. 19, 19, 11	90	1
10A	149	L. 7, 10, 8 Mean = 8 X. 9, 5, 8	100	1
11A	146	L. 7, 9, 10 Mean = 8 X. 9, 6, 7	100	1
British				
1B	121	L. 28, 26, 30 Mean = 25 X. 28, 26, 14	80	¾
2B	116	L. 27, 26, 20 Mean = 20 X. 14, 19, 17	75	¾
3B	126	L. 30, 38, 33 Mean = 27 X. 17, 24, 20	75	¾
4B	134	L. 35, 27, 49 Mean = 30 X. 21, 27, 23	50	¾
5B	126	L. 40, 35, 40 Mean = 33 X. 25, 28, 30	50	¾
6B	128	L. 18, 16, 16 Mean = 15 X. 12, 13, 14	100	1
7B	121	L. 19, 23, 14 Mean = 18 X. 18, 20, 16	90	1
8B	118	L. 24, 14, 15 Mean = 14 X. 10, 10, 12	90	1
9B	131	L. 13, 20, 18 Mean = 17 X. 16, 20, 15	90	1

TABLE V.—*Tensile-Test Results, "As Received" or "As Rolled."*

Plate No.	Maximum Stress, Tons per sq. in.	Yield Point, Tons per sq. in.	Limit of Prop. Tons per sq. in.	Elongation, per cent. on 8 in.	Reduction of Area per cent.	Thickness, in.
American						
2A ..	L. 27·7	13·7	11·5	28·0	50	¾
	X. 27·3	13·9	12·0	30·0	52	
4A ..	L. 26·9	15·8	13·7	29·5	55	¾
	X. 26·9	15·8	13·7	29·0	49	
6A ..	L. 27·6	15·4	12·4	30·0	32	¾
	X. 27·7	14·5	12·0	22·0	49	
British						
5B ..	L. 30·5	15·8	12·8	27·6	49	¾
	X. 30·8	15·8	12·8	26·0	48	

THE POSITION OF BRITISH SHIPPING.

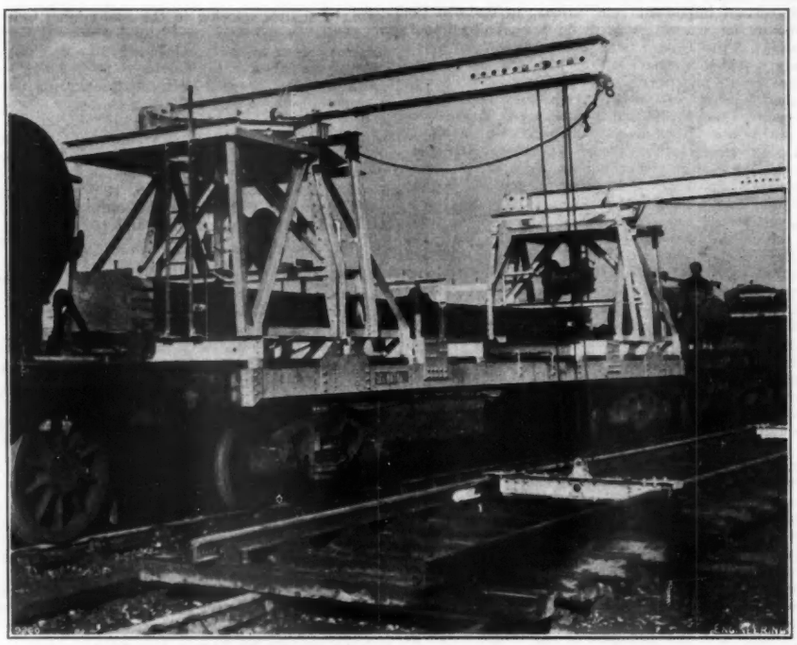
THE annual report for 1947-8 of the Chamber of Shipping of the United Kingdom lists nine "outstanding developments" of 1947 as being notable in their effect upon British shipping. First among these is the progress made in the re-establishment of the British mercantile marine by new building and by the acquisition of ships from the United States; as a result, the United Kingdom fleet, which amounted to 17¾ million gross tons in 1939, but lost many millions of tons during the subsequent war, was restored to 16½ million tons at the end of 1947 (excluding about a million tons still to be returned to the original owners) and had a further 1½ million tons on order from British shipyards. The second and third items in the list are the passage through Parliament of the Transport Act—and especially its provisions regarding ports and the maintenance of coastwise shipping services in relation to publicly-owned inland transport; and the transfer from the Ministry of Transport to the shipping industry of the responsibility for the allocation of tonnage to the import, export and other Government programmes. It is pointed out, however, that this revised arrangement does not involve the decontrol of shipping, as the Minister still controls freight rates on many routes. A further step towards what may still be regarded as "normal," however, and one which takes rank as an "outstanding feature" of the period under review, was the resumption of the pre-war practice of international co-operation through the International Shipping Conference, the Comité Maritime International and the International Chamber of Commerce.

The fifth of the important matters discussed in the report is the action taken by the Government, in collaboration with the shipping industry, to investigate the causes of delay in the turn-round of ships in United Kingdom ports, and "to suggest means of improving present performance and initiate action to that end." It is stated that investigators have already visited London, Liverpool, Hull, the North-East Coast, the Bristol Channel, the Clyde and the Forth, and that sundry reports and recommendations have been submitted to the appropriate port authorities. Next in order in the list of significant developments is the nationalisation of the coal mines, the establishment of the National Coal Board, and the seaborne traffic in coal—into the British Isles for a short period, but now outwards again, though only on a very small scale. The supply of bunker oil, however, has become more difficult to maintain during the period covered by the report, and it is stated that some owners have been notified by the oil companies that contracts for bunker oil supplies cannot be renewed in 1948.

The establishment of the independence of India and Burma, included in the Chamber of Shipping's list of developments, may not appear to have any obvious effect upon the operations of the industry, but it is conceivable that subsequent events may show otherwise. Before these changes took place, a movement was on foot in India for developing "a strong Indian mercantile marine"; and a report was issued by a Shipping Policy Reconstruction Sub-committee, appointed by the then Government of India, suggesting State financial aid for the purchase or construction of a considerable tonnage of shipping. A conference was arranged between representatives of Indian shipping and of the British Conference lines, but nothing tangible resulted from it; now, it is understood, the Indian shipping companies are in consultation with the new Government of India on the subject.

The shortage of bunker oil, which is the eighth item of recognised importance, has been mentioned above. The ninth and last, namely, the continued rise in shipbuilding prices and in operating costs, is given particular point by recent cancellations of ships which had been ordered from British yards. These are not referred to in the report, except for the observation that the great increase in building costs have hit the passenger-liner companies in particular; but the Chamber regard it as "very disturbing . . . that, in contradistinction to experience, after the last war, prices show no sign of falling, two years after the end of hostilities; and, indeed, are rising, with no sign of a diminishing rate of increase."

PLANT FOR LAYING PRE-ASSEMBLED TRACK.



TRACK RELAYING IN POLHILL TUNNEL.

THE prefabricated method of track renewal on the Southern Region of British Railways,* in which complete 60-ft. lengths of old track and new track are removed and laid, respectively, has now been applied to work in tunnels, and other confined spaces, by the introduction of a new plant for lifting track in such places. It will be recalled that the established method of renewing track by the prefabricated method is to lift a length of old track with a lifting girder and a mobile crane running on the adjacent line, place it on a flat wagon, lift a new piece of track, and lay it on the ballast bed, which has been raked over while the crane was out of the way. A train of empty wagons, to receive the old track, and loaded wagons carrying the new track, is situated nearby, and is shunted along as relaying progresses. The method is a considerable improvement on the older practice of laying and removing tracks in pieces. It is not necessary to occupy the track for several hours beforehand, while new rails and sleepers are dumped at the side of the line; the time for renewal at the site is less; and the old track is speedily removed, instead of being left to be picked up by another special train which occupies the line for another period. The labour required on the site is less—an obvious advantage—but, of course, more labour is required at the prefabrication depot. The principal limitation of the method, apart from the difficulties that would be encountered at junctions, has been that it is only practicable where there are two parallel tracks (one to be renewed, and one for the crane), and where there are no restrictions on the movement of a crane due to a tunnel or retaining wall. This limitation has now largely been overcome by fitting a bogie wagon with two jibs, as shown in the accompanying illustration. The plant is not shown in use for relaying, but is lifting, for demonstration purposes, a length of track which rests on the permanent way.

The first important relaying job on which the plant has been used is the renewal of the track in Polhill Tunnel, between Knockholt and Dunton Green, on the boat-train route to Tonbridge and Dover. This work was started on the night of Saturday, February 21, and the tunnel is closed to all trains, except a few at the rush hour each morning, until Sunday, March 14. The plant consists of two jibs mounted on a "Warflat" bogie wagon, 40 ft. in length over the headstocks, and with a tare weight of 18 tons 3 cwt. Each jib swivels on a semi-circular turntable mounted on a frame at one end of the wagon, and the two jibs are swung into line with each other, and with the wagon, and locked there for travelling. When in use for lifting, they are swung out to one side. An air-motor winch, supplied with compressed air from a compressor set on an adjacent wagon, is fitted to each end frame. The lifting fixtures each consist of a fabricated frame, with a central pulley, and two sliding pins which lift the track underneath the rails. In order to counterbalance the weight of a 60-ft. length of track when it is being lifted, and thus prevent the wagon from overturning, a "nest" of rails, weighing approximately 17 tons, is laid along the opposite side of the wagon. This counterbalance weight may be moved from one side to the other, as required, or placed centrally for travelling. By permission of the Chief Civil Engineer, Mr. V. A. M. Robertson, M.I.C.E., we recently had an opportunity to see the equipment in use, on a Sunday morning, for relaying track in the open; not in a tunnel. On the site in question, there was a wall alongside one of the tracks, which would have hampered the movements of a crane. The plant had been marshalled at the end of a short train consisting, in addition to the plant, of the compressor-set wagon, a brake van, and a locomotive. The two men at the winch controls, the man in charge on the permanent way, and the driver and guard of the train, appeared to experience little difficulty in co-operating to ensure expeditious lifting and relaying of the track.

The Polhill Tunnel, which now contains two electrified tracks, was first opened to traffic in March, 1868. It is 17¼ miles from London, and is bored through the chalk of the North Downs, at a maximum depth of 220 ft. below ground, and on a gradient of 1 in 143, falling away from London. The work now being undertaken over a period of three weeks includes relaying the tracks, removing the old ballast and spreading new ballast, and improving the drainage system. The track is usually relaid every four years, at several week-ends when the Chief Civil Engineer's Department has possession of the line, but the extent of the work on this occasion would require 26 week-ends; it was therefore decided to close the tunnel, as already explained. For some time, it has been necessary to impose a speed limit of 30 m.p.h. on the up line, and 45 m.p.h. on the down line, owing to the fact that approximately the centre third of the tunnel is waterlogged. The chalk, soot, etc., in the tunnel have clogged the ballast, and a recent analysis showed that it was 11 per cent. dry chalk, 18 per cent. carbonaceous matter, and 71 per cent. dirty ballast. The drainage system consisted of a 9-in. concrete-channel drain running through the tunnel on one side, and a 6-in. porous-concrete drain in the waterlogged area, connected to the 9-in. drain. The ballast was laid on a brick-rubble bed. In addition to relaying the track with standard 95-lb. bull-head rails, with 27 sleepers to each 60-ft. length, the ballast is being renewed for the whole of the tunnel, but more deeply in the waterlogged area, where a Blaw-Knox "Insley" ½-cub. yard excavator, with skimmer attachment, is being used to excavate about 2,500 tons of material. This plant is particularly suitable for work in tunnels, because the cab remains stationary when the jib is slewed; with the usual type of excavator, the cab would foul the tunnel wall. Precautions have been taken to ensure that the men in the tunnel are protected from carbon-monoxide poisoning.

The total amount of old ballast to be removed is about 4,000 tons. Two shifts, of 130 men each, are employed in the tunnel, and 60 men are engaged in disposing of the excavated material outside the tunnel. A total of 56 trains, for transporting the new and old tracks and ballast will be run to the site. While the work is in progress, trains which would normally use the tunnel are being diverted via Otford and Swanley, except that between 7.45 and 10 a.m. about half the up steam trains will use one line through the tunnel.

* See ENGINEERING, vol. 162, page 332 (1946).

STANDARD FRAMES FOR FARM BUILDINGS.

THE Ministry of Agriculture and Fisheries have prepared designs for a range of standard ridged-roof trusses, purlins, posts, etc., for farm buildings, and have arranged for manufacturers and distributors to make and sell the components to persons with building licences, commencing some time in May. Generally, the M.A.F. buildings—as they are called—are made from angle iron, etc., recovered from air-raid shelters, but some of the components are of reinforced concrete. There are two widths of span to choose from: 17 ft. 6 in. and 32 ft. 3 in. between walls, and the length of bay is 15 ft. in both cases. The buildings may be erected with either framed or weight-bearing walls. For the former, standard reinforced-concrete posts have been designed, 8 ft., 12 ft., and 16 ft. high (to the eaves). Infilling may be solid, of brick, concrete, or other blocks; or the sides may be sheeted; or a combination of solid infilling and sheeting may be used. Weight-bearing walls may be built to any suitable height. It is not essential, of course, to build four walls round the erected frame; one or more may be left open, with only the posts supporting the roof trusses, as in the case of grass-drying sheds, etc. Indeed, the frames allow considerable latitude in the choice of height, length (multiples of 15 ft.), width (multiples of either of the two alternative spans), and the material of the roofs and walls. They can therefore be used for a wide variety of purposes—for cow houses, dairies, milking houses, piggeries, workshops, implement sheds, covered yards, stables, loose boxes, stores, shelters, etc.; and there is no risk of farm buildings becoming standardised in appearance.

The small ridge-roof truss has an overall span of 18 ft. 4½ in., and is made from angle irons, 2 in. by 2 in., 2½ in. by 2½ in., and 3 in. by 2½ in. The rafters are inclined at an angle of 23 deg. 4 min., and are provided with three purlin cleats to each rafter. The eight members in each truss are welded together. The large truss, 33 ft. 10¼ in. overall span, is formed by joining two small trusses. The lower-chord tie-bars of the small trusses become the rafters, and the lower-chord tie-bar of the large truss is completed by bolting a length of angle-iron between the two small trusses. The inclination of the roof is still 23 deg. 4 min., but each rafter is fitted with five purlin cleats. The purlins, 15 ft. in length, are either of reinforced concrete, or are box sections pressed from Anderson-shelter sheet. The reinforced-concrete purlins are L-shaped in section, except for rectangular-section pieces at each end (with bolt holes for attachment to the cleats), and four webs spaced at equal distances over the length. The eaves units, also, can be of either reinforced concrete or steel box section, the concrete units being approximately channel sections. Wind-bracing bars are approximately 17 ft. 4 in. by 2 in. by ¼ in., and attached by a ⅝-in. bolt at each end. For the gable ends of a building, reinforced-concrete beams and posts have been designed. The posts along the side of the building are of H-section reinforced concrete. All joints are bolted together, and any number of bays, or spans, may be erected. Special reinforced-concrete posts are made for supporting the ends of two adjacent trusses. The floor area of one bay of a small span is 262·5 sq. ft., and that of one bay of a large span is 483·75 sq. ft.

The Ministry of Agriculture expect that 70,000 small trusses and 320,000 purlins will be manufactured during 1948 and 1949. The selling costs are not yet known, but are expected not to exceed, and may be less than, present building costs. The Ministry are confident that there will be no shortage of other materials, such as bricks, sheeting, doors, windows, etc., when the pre-fabricated trusses are delivered to the building sites. It is stated that specimen buildings will be exhibited during the summer at the principal agricultural shows. In reply to a question in the House of Commons on Monday, February 16, the Minister of Agriculture, Mr. T. Williams, stated that delivery could be expected within seven days of placing an order. The scheme had been prepared by his Ministry, the Ministry of Works, and certain associations. The Minister of Food had informed him that, in the opinion of the Overseas Food Corporation, buildings erected with these components would also be of great value to the East African ground-nut scheme.

NOTES ON NEW BOOKS.

British Locomotives at Work. By O. S. NOCK. Greenlake Publications, Limited, 156, Camden High-street, London, N.W.1. [Price 16*s.*]

MR. O. S. NOCK is one of the select band of footplate travellers, and this book is a record of some journeys he made in England between 1934 and 1939. Some of the information has already appeared in periodicals, but in the present form the author has incorporated notes on locomotive developments which are complementary to the recorded performances. In the first two chapters, Mr. Nock refers to the influence of the Swindon tradition, and describes some runs on Great Western "Saint" and "Star" class locomotives. The effect of the influence is seen in later chapters dealing with Sir William Stanier's 4-6-2 and 4-6-0 locomotives on the L.M.S., and the "Pacifics" of the L.N.E.R. The author recounts footplate trips on most of the principal types of locomotives of the period, but regrets the omission of detailed reference to the G.W.R. 4-6-0 "King" class. There are two interesting chapters on the Great Northern "Atlantics" and the 4-4-0 "Schools" class of the Southern Railway; in the latter case, Mr. Nock refers to the renaissance of the 4-4-0 type, which was, indeed, remarkable. The book contains many reproductions of photographs, outline drawings, and principal data on locomotives, gradient profiles and maps of lines, and a few performance curves. There is a reference on page 148 to an "accompanying diagram" of results, but it has apparently been omitted. It must be an almost impossible task to retain the interest of the reader when describing a long run, since he is expected to visualise gradients, distances, curves, booked times and actual times, in addition to speeds, cut-offs, steam pressures, train weights, power developed and other variables. This is not easy for the reader, especially if he is not familiar with the line, but perhaps it is a small price to pay in return for such unique information. In an appendix to the book, Mr. Nock explains his method of calculating locomotive horse-power, which is used for comparing locomotive performances in the main text. The resistance of the train is calculated from Dr. F. C. Johansen's formula, and the gradient resistance is obtained in the normal manner. In addition, however, the author adds the gradient resistance of the locomotive and tender, in order to make reasonably fair comparisons, and designates the total power on this basis "drawbar horse-power." It would, of course, be better to refer to "equivalent drawbar horse-power on level track," or, more simply, "rail horse-power"; and, in any case, the first use of "drawbar horse-power" in the book is misleading without a reference to the explanation given in the appendix.

Fundamentals of Electricity and Electromagnetism. By PROFESSOR VERNON A. SUYDAM. Fourth edition. D. van. Nostrand Company, Incorporated, 250, Fourth-avenue, New York, U.S.A. [Price 5.50 dols.]; and Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 27*s.* 6*d.* net.]

OWING to the dearth of modern English works on electricity and magnetism, students in this country are compelled to rely increasingly upon American texts. Of these, Professor Suydam's book is a good example, providing a sound and comprehensive course of degree standard. The classical topics in electricity, magnetism and electromagnetism are clearly presented, with the old and new points of view compared and contrasted throughout. Features that will appeal particularly to the engineer are the detailed descriptions of electrical measuring techniques, which are of increasing importance because of the growing tendency to translate a quantity to be measured into its electrical counterpart; and the thorough treatment of alternating currents, which occupies nearly one third of the text. The extent to which recent developments can be covered in such a course is always a problem, but it is a pity to have excluded the cyclotron and other forms of electron and ion accelerators that have made artificial transmutation possible. By now, no doubt, English readers will be reconciled to expressions such as "hook up" and "making the grade" though he may blink at the "Holland physicist." There are a number of misprints, such as cm. sec. for cm. sec^{-1}, on page 75, and $\sin^2\theta$ for $\sin 2\theta$ and a missing θ on page 353. In the statement of Ohm's law on page 179, "at constant potential" should read "at constant temperature," while μf. is a more usual abbreviation than mf. for microfarad. Contrary to the impression conveyed on page 674, Rochelle-salt crystals are commercially available and give reliable service in pick-ups, microphones and louds peakers. Some justification is needed for the omission of even harmonics and phase constants in the expression for the E.M.F. developed by a dynamo, on page 494. Useful sets of examples are included, but no answers are provided. The list of references at the end would be more readily consulted if it were arranged alphabetically.

LABOUR NOTES.

AT a special meeting on Wednesday last week, the General Council of the Trades Union Congress decided, with certain important reservations, to endorse the proposals on wages set forth in the White Paper, provided "the Government pursues vigorously and firmly a policy designed not only to stabilise but to reduce profits and prices." In a statement circulated on the following day to the executives of the affiliated unions, the Council said that they believed the principles in the White Paper were acceptable to the Trade Union Movement to the extent that they (1) Recognise the necessity of retaining unimpaired the system of collective bargaining and free negotiation. (2) Admit the justification of claims for increased wages where these claims are based on the fact of increased output. (3) Admit the necessity of adjusting the wages of employers whose wages are below a reasonable standard of subsistence. (4) Affirm that it is in the national interest to establish standards of wages and conditions in under-manned essential industries in order to attract sufficient man-power. (5) Recognise the need to safeguard those wage differentials which are an essential element in the wages structure of many important industries and are required to sustain those standards of craftsmanship, training, and experience that contribute directly to industrial efficiency and higher productivity.

In the statement circulated to the executives of affiliated unions and to be discussed at a full meeting of executives on March 24, the Council invited all trade unions to consider their individual wage policies in the light of the principles laid down in the White Paper. They do not believe it to be practicable to propose that unions should actually withdraw all wage claims that have already been tabled or are the subject of current negotiations, but they think that executives should re-examine the claims with a view to bringing them into conformity with the principles of the White Paper as qualified by the T.U.C.'s reservations. The Government's wage policy, "as qualified by the T.U.C.'s reservations," the General Council suggest, should be reviewed in detail immediately after the introduction of the Budget and thereafter—at intervals of not less than three months.

At Manchester last week, employers and trade unions representing the cotton-weaving industry accepted proposals which, in effect, would set up a new wage structure in the trade. The proposals, which were contained in a report by the Moelwyn Hughes Commission, urge wider adoption of the "more looms to a weaver" system, and stipulate that weavers should "tend" six or eight looms instead of the normal four. It is claimed that by these means output can be increased by at least 250 million square yards of cloth a year, enabling exports of Lancashire piece goods to attain their 1948 target of 786 million square yards.

The Cotton Board announced last week that there had been a net man-power gain averaging 267 weekly for the industry during the last four weeks in January. A survey of the labour situation in cotton mills last year showed that the number of operatives on the books of spinning, doubling, and weaving firms rose to 268,610—which was about 20,000 more than at the beginning of the year. Effective employment was still less than 70 per cent. of the 1947 figure, while machine activity compared with total installed machinery, was 66 per cent. in spinning, 70 per cent. in doubling, and 53 per cent. in weaving. By the end of last year, 2,919 girl workers and 400 men from camps for displaced persons in Europe had arrived for employment in Lancashire mills. The introduction of housewives' shifts of four hours each evening proved highly successful, and in the spinning section alone, the number of part-time women on the books increased from 3,310 to 6,350 in the four months from June to September.

The Ministry of Labour and National Service states that an exceptionally large outflow of women accounted for a decline during December in the working population from the high levels reached in the two previous months. The working population of 20,423,000 at the end of December was 33,000 less than in November. The number of men in industry increased by 14,000, but the number of women decreased by 47,000—20,000 of whom were part-time workers, most of them in distribution and consumer services.

In spite of the decline, the total working population at the end of the year was still 60,000 greater than at the end of September, 1947, just before the introduction of the Control of Engagement Order. The number of unemployed rose from 277,200 at December 8, 1947, to 318,200 at January 15, but it is explained in the Ministry's statement that up till December 8 the figures excluded persons unsuitable for ordinary employment.

Official figures relating to the coal-mining industry show that in the week which ended on February 7, output per man-shift continued to decline and absenteeism slightly to increase. At the coal face, man-shift output was 2·89 tons against 2·92 tons in the previous week and 2·73 tons last year. Overall, it was 1·09 tons compared with 1·11 tons in the previous week and 1·03 tons last year. Voluntary absenteeism among coal-face miners was 8·12 per cent., compared with 8·20 per cent. in the previous week and 12·59 per cent. on February 8, 1947; involuntary absenteeism was 6·63 per cent., compared with 6·49 per cent. in the previous week and 10·2 per cent. at February 8, 1947.

Mr. Beard, the general secretary of the United Pattern-makers' Association, deals with the shortage of hand tools in the latest issue of the organisation's *Monthly Trade Report.* "Members," he writes, "will know that the shortage of tools, particularly of the gouge and chisel type, has been creating difficulties . . . and I am sure has, to some extent, impeded production. Formerly, we were able to get the Ministry to transfer tools to areas where shortages occurred, but, unfortunately, of late, the shortages have been manifest almost throughout the country. Indeed, in case of fire or complete loss of tools, in some instances, many months have elapsed before we have been able to finalise the Society claims, and it is obvious that something must be done in the matter. The Ministry of Supply concur in that view, but to enable them to give instructions to the manufacturers of gouges and chisels, it is necessary to try to obtain, if we can, some sort of a census of the demand in our Association, and I have addressed a circular on the matter to branch secretaries which, I hope, they will treat as urgent, and let me have the information required as soon as possible."

"Many suggestions," Mr. Beard continues, "have been made by branches to meet this tool shortage, one of which is that members who are leaving the trade, such as super members, might have tools for disposal and that the problem of getting these members into touch should be dealt with by the General Office. While the suggestion, in itself, is a good one, there are obvious difficulties in dealing with the matter at national level—not only the question of getting the two parties into touch with each other, but also that of obtaining their agreement as to condition and price. The E.C. have instructed me to suggest that the question might be dealt with on an area basis."

At a conference in London on Thursday last week, representatives of the National Union of Mineworkers discussed with representatives of the National Coal Board the question of overtime working during the current year. On the working of overtime, it is estimated, depends the achievement of the 1948 coal target. No decisions were reached; but, on the following day, the Mineworkers' executive decided to recommend to a special delegate conference that the working of extra time should be continued for twelve months after the expiry of the present agreement. The delegates are to meet on April 2. It is regarded as probable that many pits will abandon Saturday working and decide to work the extra half-hour a day as Northumberland and Durham are doing. The White Paper on wages is to be discussed at special meetings of the Mineworkers' executive at Nottingham on March 11 and 12.

According to the writer of the "Notes and Comments" in the February issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, the men in the industry are surprised that in their planning, the Government are disregarding the human factor. "For years," he says, "the steel workers have more than pulled their weight on rations which are not greatly in excess of those granted to an attendant in a pin-table saloon; but how much longer can they be expected to go on doing this? Are not the Government—and the Minister of Food in particular—aware that the maximum physical effort is required of workers in the iron and steel industry and that there are definite limits to the amount of strain and fatigue to which the human constitution can be subjected." "Repeatedly, in the past," he goes on, "unavailing efforts have been made to convince the Government of the necessity of making some improvement in the rations granted to iron and steel workers, and more recently an application for an extra pennyworth of meat per meal served in steelworkers' canteens was turned down by the Ministry of Food; yet not only is the steelworker asked to keep up the magnificent pace he has set, but is also, it seems, expected, as a matter of course, to increase his efforts still further."

AUTOMATIC LIFTS ON LONDON UNDERGROUND RAILWAYS.

FIG. 1. LIFT-MACHINERY AND MAIN CONTROL BOARDS AT EARL'S COURT.

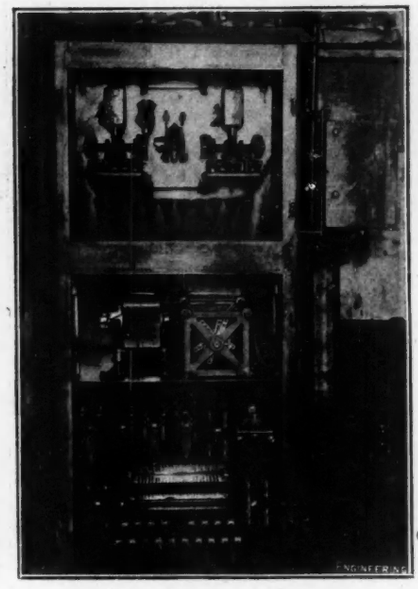


FIG. 2. AUTO-CONTROLLER DRUM SWITCH.

AUTOMATIC LIFTS ON LONDON UNDERGROUND RAILWAYS.

THE operation of London's extensive system of deep-level underground railways obviously requires the provision of means whereby the passengers can be conveyed between the platforms and the streets both easily and expeditiously. When these railways were opened at the beginning of the century, the stations were, therefore, equipped with lifts, all of which were arranged for operation by a lift attendant, who worked a controller in the cage itself. This arrangement was adequate in the earlier days, but the increase in traffic and growing labour difficulties necessitated the conversion, between 1920 and 1925, to a system of landing control for lifts. This enabled a group of lifts to be operated from each landing by one attendant. In this way it was possible to reduce the staff allocated to lift operation, even at the busiest stations. At the same time, the original system of compressed-air operated exit gates and hand-operated entrance gates was replaced by pneumatic engines, which were controlled by electrically-operated valves, the latter, in turn, being actuated by switches either on the landings or in the cages. Additional safety devices were installed to ensure that the lift-control switches were correctly adjusted for slowing down and stopping at the landings, while "police limits" were fixed at an intermediate position in the shaft to ensure that these devices were operating properly each time a trip was made.

With the installation of escalators at the busier stations, which began about this period, lifts became of less importance as a means of handling the traffic, although equipment of the type just described continued in use at places where the traffic was moderate, or where escalators could not be installed. An exception to this rule is the completely automatic lifts, which are in operation at Earl's Court, Strand, Goodge-street and Oxford-circus, either as the sole means of dealing with the traffic or to supplement the escalators. As it is nearly 20 years since the first of these automatic lifts was installed, an account of their development may be of interest.

In 1928, the first completely automatic installation was brought into use experimentally on No. 2 lift at Warren-street on the Northern Line. This installation, which was designed to effect automatically the switch movements hitherto carried out by the operators on the landings, consisted essentially of a motor-driven switch of the barrel type. The motor, being shunt wound, ran at a speed sufficiently constant for practical purposes, while the switch itself consisted of a number of contacts, which could be closed in order, and, if desired, at predetermined intervals. These contacts were connected to relays, the operation of which closed or opened circuits on the lift machinery. All the existing safety devices were retained. In addition, an alarm was fitted in the cage for the use of passengers, while a governor was provided which rang a bell if the lift stopped in the shaft. Illuminated signs were placed in front of the landing doors and cage exit gates. These showed "Gates closing" before the cage began to move, while at the same time a buzzer was sounded. The equipment was arranged so that the lift could be operated as an independent unit or with a "pilot" lift. In the latter case, the "piloted" lift left the landing as the "pilot" approached it, and was maintained in step with the latter by adjusting the contacts on the sequence switch. The landing time of the former was thus reduced, this being the last operation which was performed before the lift was dispatched. This equipment was taken out of service at Warren-street in 1929, after the experimental work on it had been completed.

The equipment just described, together with another similar to it, was installed on Nos. 3 and 4 lifts at Earl's Court at the end of 1932. An illustration of the lift machinery and main control boards used at this station is given in Fig. 1, while the auto-controller drum switch is illustrated in Fig. 2. At the same time as this conversion took place, landing control gear was added to the lifts, so that it became possible to operate them either automatically or from the cage. At the present time, No. 3 lift at Earl's Court is generally used as the "pilot"; that is, No. 4 is started automatically when No. 3 leaves the landing. They may, however, be run independently. After a number of experiments a bell was installed to give warning that the gates were about to be closed, but this has now been replaced by a loudspeaker. The two lifts at Earl's Court have a rise of 63·5 ft. and run at a speed of 180 ft. per minute, so that the travelling time from landing to landing is 22 seconds. Each lift is capable of carrying 50 passengers and 30 round trips an hour can be made.

Three years later automatic equipment was installed on three existing lifts at the Strand station. In this case, however, the timing of the operations was controlled by impulses sent out from a chain of slow-dropping relays which were used to move a master selector relay at a predetermined rate and thus to transmit the starting impulse to the equipment on each lift at the correct intervals. The timing of these impulses could be adjusted so that, with two lifts working, one was at each landing, while when three lifts were working one was at each landing and the third in transit. Each lift was controlled through appropriate selector switches and relays, which operated contactors and so closed or opened the various operating circuits. As the main lift equipment was not arranged for landing control, the same modifications were necessary as at Earl's Court. It was found more suitable, however, to remove all the limit switches, except the ultimate limits, from the shaft and to install them in the machine room, where they are operated mechanically by a steel tape from the cage. Loudspeakers are installed to give notice that the lifts are about to start. These are supplied from "variable area" sound-recording equipment, in which a beam of light is passed through a film mounted on a revolving drum to impinge on a photo-electric cell. The changes thus set up in the latter are then transmitted through an amplifier to a loudspeaker. The drum is driven at a constant speed of 20 r.p.m. by a 220-volt three-phase motor, while the various relays are supplied with direct-current from the same source, through metal rectifiers. The rotation of the drum closes a contact at each revolution, so that every three seconds an impulse is transmitted to the selector relay through which the lifts are controlled and the necessary indicating signs are illuminated.

Passenger alarm switches are provided, to prevent the closing of the gate, if the cage is at a landing, or to open it, if it has already been closed; an alarm is also operated. If the lift is in motion, when the alarm is operated on arrival at the landing only the exit gates are opened and the lift remains in this condition until the necessary attention has been given. If the visible warning signs fail for any reason, the alarm operates and the gates are not closed, while if the lift does not start the gates are re-opened to allow the passengers to alight and the alarm is sounded. This alarm continues for about 4½ seconds, after which the landing cycle is repeated, in order that another opportunity may be given for the lift to take up its correct position in the cycle. If the operation of the gates is interfered with by passengers, or the lift does not leave the landing promptly for other reasons, the alarm is sounded for 2 seconds. A continuous alarm is also given if the lift stops in the shaft, while a humming noise is set up if the speech equipment fails to operate. The rise at the Strand is 39 ft. and the lifts run at a speed of 180 ft. per minute, so that the time taken to travel from landing to landing is 14·5 seconds allowing 35 round trips per hour to be made.

In 1937, a battery of three automatically-operated lifts was installed at Goodge-street station, the shaft originally occupied by two manually-controlled lifts being utilised for this purpose. These lifts were designed to operate at a speed as high as 600 ft. per minute and were driven by equipment of the gearless type with variable-voltage control, as opposed to the older machines which were of the drum type. On this equipment the hoisting sheave is directly coupled to the armature of the main motor, the brake drum being integral with it. Power is supplied from the 600-volt direct-current traction system to a combined motor-generator and exciter set, the latter not only feeding the fields of the lift motors, but certain of the control circuits. The generator is connected direct to the main motor armature, the direction of the current and the voltage being determined by appropriate variations of the field, which is controlled from the main switchboard. Both the safety devices and the automatic control equipment are similar to those installed at the Strand, i.e., the correct spacing of the lifts is maintained by a master selector relay, while the various operations are initiated by subsidiary relays. Equipment is provided whereby the closing of the exit gates is

announced on loud speakers inside the cage, while the closing of the entrance gates is similarly indicated by loudspeakers on the entrance sides of the landings. Illuminated signs are also provided which work in conjunction with these loud speakers and show which is the "next lift" that will be available. Control boxes on each landing and in the cages enable non-automatic operation to be introduced, while for maintenance purposes the lifts can be controlled from the machine room or the top of the cage. The capacity of each of the lifts is 22 passengers and the travelling time in the 85-ft. shaft is 12 seconds, so that 33 round trips per hour can be made.

To meet the increase in traffic which it was anticipated would occur as the result of the opening of the eastern and western extensions of the Central Line, a pair of automatically-controlled high-speed lifts were installed at Oxford Circus in 1942. These lifts are capable of carrying 50 passengers and run at 500 ft. per minute. The shaft is 75 ft. deep and the travelling time from landing to landing is therefore 13 seconds, while 32 round trips per hour can be made. Like those at Goodge Street, these lifts are equipped with gearless drives and variable-voltage control. They are arranged to serve three landings at the platform, booking hall and street levels respectively, and are operated according to three different duty cycles. When the first of these is in use the passengers are loaded at the platform and are conveyed to the street level, where the gates open directly on to the street. The lift then returns empty to the platform level. In the second cycle of operations passengers are loaded at the booking hall level and are conveyed to the platform level, the lift then returning empty to the booking hall; while in the third the passengers are loaded at the booking hall level and conveyed to the platform level, where a further batch of passengers are loaded. The lift then ascends loaded to the street level and descends empty to the booking hall.

Owing to the layout at Oxford Circus, it was impossible to construct through passages at the different landings. Unloading and loading have, therefore, to take place on the same side of the lift at each landing. Doors are, however, provided at each end of the lift, as all the landings are not on the same side. It was for this reason that it was decided that the lifts could best be used in conjunction with the escalators to convey passengers in one direction only, as in the first two cycles of operation, although the third cycle is available, if it should become necessary to operate them in both directions. As is the case at Goodge Street, the lifts can, if necessary, be operated from either the cages or the landings, as well as from the machine room or cage top. A switch is also provided at the booking hall level, so that the cage can be dispatched therefrom to the street level at slow speed.

ALTERNATING CURRENT FOR SHIPS' AUXILIARIES.*

By A. N. SAVAGE.

THE desire for greater simplicity and economy is leading to more alternating-current plant being installed on American and Continental ships. In the case of a Messageries Maritimes ship, direct-current is being completely replaced, and alternating current is also to be employed on three 7,500-ton cargo liners which are being built for Cie Générale Transatlantique.

The chief disadvantage of an alternating-current supply has been the inability to obtain the variable-speed motors which are deemed essential for certain drives. To-day, however, motors with a speed range of 10 to 1 are available but, since they are expensive, the number installed should be kept as low as possible. The use of constant-speed and two-speed motors may lead to a certain loss of flexibility. On the other hand, it is questionable whether the number of variable-speed motors employed on direct-current installations is really necessary. The advantages of an alternating-current system are that the squirrel-cage motor, with direct-on starting, can be used for the majority of drives, the results being a gain in simplicity and a reduction in first cost, maintenance and weight, compared with the direct-current equivalent. On the larger installations, where a three-wire 400-volt system of distribution with transformers supplying the low-voltage circuits, is economical, the load can be sectionalised with a consequent reduction in fire risk. With the recent increase in loads, it has become more and more difficult to space and bunch cables in the room available. With alternating current systems, using the higher voltage advocated, the number and size of the cables, however, can be reduced, with a consequent saving in weight and cost and improved spacing. Electrolytic action will also be practically eliminated.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders on Friday, February 6, 1948. Abridged.

The system of distribution generally adopted is to supply a suitable number of master boards, situated in various compartments of the vessel, through individual feeders from the main switchboard. These master boards in turn, control the supply to section and fuse boards, as indicated in Fig. 1, opposite, where *a* and *b* are the lighting and heating circuits, respectively, *c* the ventilating plant circuits, and *d* the circuits for the deck machinery. The motors for equipment which is essential for the propulsion and safety of the vessel, such as boiler fans, oil-burning apparatus, lubricating-oil pumps, steering gear and navigational lights, is supplied through separate cables. Should a generator circuit-breaker open, provision is made for relieving the load on the remaining generators. The most suitable method of doing this is by a tripping relay, which is energised by a second relay.

On installations with connected loads of 5,000 kW or more, the three-phase three-wire system of distribution should be considered. On such an installation, the use of air-cooled transformers for supplying the lower-voltage heating, cooking and lighting circuits, as shown in Fig. 1, opposite, will be economical. As will be seen, individual transformers are used to supply the various master boards, an arrangement which has the advantage of dividing the installation into a number of electrically-isolated sections. An earth fault on one section is therefore unaffected by a similar fault on any other section, this reducing the fire risk and the chance of incorrect operation. A further advantage is that it is possible to balance the lighting, heating and cooking loads. In spite of its lower initial cost, the three-phase four-wire system with earthed neutral is not suitable for marine purposes, as a short-circuit on one phase would impose severe mechanical stresses on the generator windings and might have unfortunate consequences if the fault were on an essential circuit. An insulation failure, not necessarily constituting a solid earth, might cause arcing with the attendant risk of fire. The use of a three-phase four-wire system with insulated neutral would eliminate the installation of transformers except on the lighting circuits. Its initial cost is lower than that of the three-wire system, although the advantages of sectionalisation would have to be sacrificed; and it has not the drawbacks of the four-wire system with earthed neutral. The larger individual loads, such as galley ranges, can be divided between the three phases and neutral, in order to obtain reasonable balance. Provided all the live parts are enclosed and all other metal work is earthed, there should be no danger of shock. In fact, it is a sound system for all sizes of installation, and should be adopted on medium and small installations where the advantages of sectionalisation are not great enough to justify the cost of installing transformers.

To avoid risk of fire in the accommodation spaces, the air-cooled transformers should be installed in lined compartments, which should be free from all inflammable material, other than that necessary for their operation and that of the attendant switchgear. In machinery spaces, where there is always a risk of saturation by oil vapour or steam, immersed transformers, cooled either by mineral oil or one of the non-inflammable chlorinated compounds, should be installed. These compounds, however, are expensive and are, moreover, powerful solvents of practically all the gums, varnishes and paints used in oil-immersed transformers. The usual connection of the transformers used should be delta/delta, three single phase units being installed so as to maintain the supply should one phase fail. Two single phase units connected in "V," as in Fig. 2, with a reactance at *b* to give balance can, however, be employed. This has the advantage that the capacity of the bank can be increased by the addition of a third transformer to obtain a delta/delta connection. The "T" connection shown in Fig. 3 is economical in first cost. As will be seen, it consists of two transformers, one of which has both its primary and secondary windings designed for 87 per cent. of the three-phase voltage. The other transformer is designed for the full voltage and both its windings are provided with taps at the middle points. To prevent unbalance the transformer impedances must be equal, or additional impedance must be inserted in the circuit.

The alternators may be driven by either turbines or Diesel engines, although the former are preferable wherever possible. The minimum number of sets should be installed so as to take advantage of the lower unit cost and to facilitate direct-on starting of the motors. Where Diesel-driven sets are required to operate in parallel, close attention must be given to speed regulation, cyclic variation and governor performance, in order to reduce the wattless circulating currents to a minimum. The emergency generating set, which gives an alternative supply to the motors on the steering gear, boat winches, fire and bilge pumps, and to the navigational and emergency lighting, is always driven by an internal-combustion engine. The starting currents of the motors connected to this source of supply should be restricted, either by using wound or high-torque low-starting-current rotors. There are no recognised rules regarding the voltage regulation of the alternators installed on board ship. The regulator, however, should be capable of withstanding the rolling and pitching of the vessel and be proof against oil vapour and moisture-laden atmospheres. The recommended practice on American vessels is that the system performance should be such that the settled voltage at any point below no load and full load will not vary by more than ± 1 per cent. from the rated generator voltage. To comply with this stipulation a costly regulator would be required. The simplest and most robust regulator is the carbon-pile type, which will maintain the voltage between no load and full load to within ± 3 per cent.

The main switchboard should be of the dead-front type in order to reduce the hazards to personnel. The generator circuit-breakers should preferably be electrically operated to permit accurate and instantaneous paralleling, and all paralleling instruments and control gear should be mounted on a central control panel. The circuit-breakers may be either air-break or oil-immersed, but, if the latter, attention must be paid to the maintenance of the correct oil level, to changing the oil after rupturing heavy currents, and to maintaining it free from moisture. Circuit-breakers must be fitted to those non-essential circuits which are required to trip under the load-relief scheme. They are also recommended for all circuits rated at 150 amperes or more, and for circuits supplying groups of motors whether single-phase protection is incorporated in the motor-control gear or not. The circuit-breakers on the power feeders should be fitted with overload trips having inverse-time characteristics. Fuses controlling individual induction motors should be capable of providing short-circuit and inverse-time overload protection. The master switchboards, with any transformers for the lower voltage circuits, should be accommodated in compartments, preferably of bare steel. Provided only members of the operating staff have access to these compartments, the switchboards may be of the open type with ample space at the back to allow of inspection and repairs. Particular attention must be paid to ventilation when transformers are installed.

Three-core cables should be used for all three-phase circuits in order to eliminate inductive effects. For 440-volt circuits they should be lead covered and armoured, and to facilitate installation cross sections larger than 0·3 sq. in. should not be used. For the lower voltage supplies, hard-rubber cables, either single-, two- or three-core, are strongly recommended. Mineral-insulated metal-clad cables may be used to great advantage for special purposes, such as galley ranges, boiler gauge-glass lights, electrically controlled soot blowers and other circuits where the ambient temperatures are high. On the larger installations the employment of this type of cable is limited by the number of terminations which are necessitated. It must be remembered also that the fitting out of the larger marine installations proceeds along with the work of platers, drillers, riveters and joiners, and while this type of cable will withstand deformation it is, like all metal-sheathed cables, subject to abrasion and puncturing of the sheath by impact with plates, and other rough treatment. With the larger single-core cables the phases should not be widely separated, as the impedance increases and the current-carrying capacity decreases the farther apart they are spaced, while the current-carrying capacity increases as the distance between the cables and steel-work is increased. For cables below 0·2 sq. in. nominal cross section the carrying capacity is increased when the sheaths are close together in contact with the steel structure, owing to the cooling effect of the latter. Where single-core cables pass through a steel bulkhead a non-magnetic gland is essential, and the fitting of a non-magnetic gland plate is recommended.

For an alternating current installation to be successful, squirrel-cage motors should always be used in preference to those of the wound rotor or synchronous types. Where a high starting torque is required, or where it is desired to limit the starting current, a high-torque low-starting-current type of motor may, however, be installed. Great care must also be exercised in assessing the power required for each individual drive in order to avoid installing oversize motors with a consequent rapid decrease in power factor. In the past, variable-speed motors have been installed without sufficient consideration of their necessity. They are, however, essential for driving the boiler fans, deck machinery and refrigerating compressors.

As regards the regulation of the motors driving the boiler fans, a practical limit of 50 per cent. of the synchronous speed can be obtained by using a wound rotor and secondary resistance, which should be closely stepped to give fineness of control. There is some energy loss with this method, but as the input decreases rapidly with the speed, this will not be great. When the steam requirements vary greatly, manipulation of the damper, as well as speed control, may be necessary.

ALTERNATING CURRENT FOR SHIPS' AUXILIARIES.

Fig. 1.

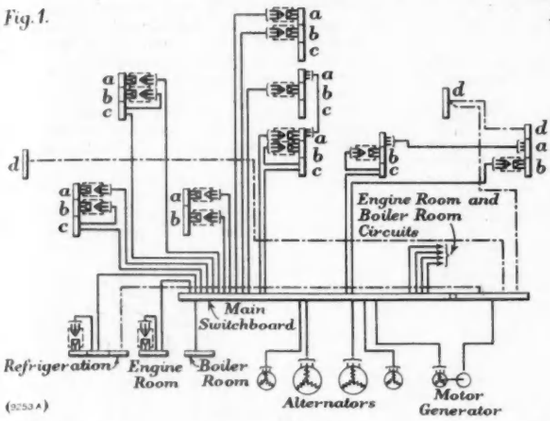


Fig. 2.

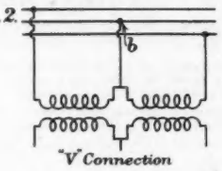


Fig. 3.

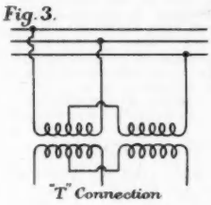


Fig. 4.

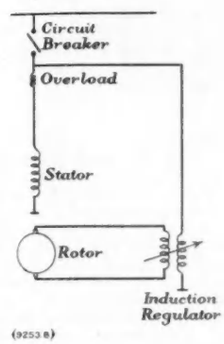


Fig. 5.

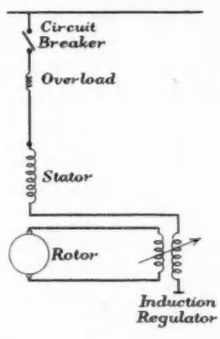


Fig. 6.

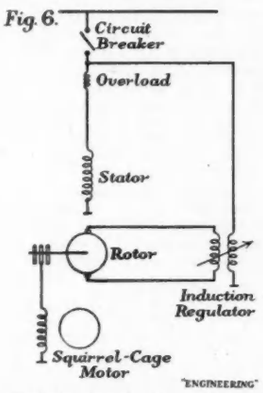


Fig. 7.

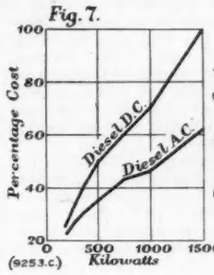


Fig. 8.

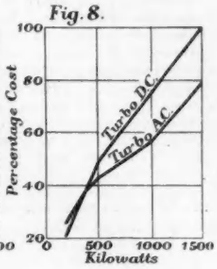
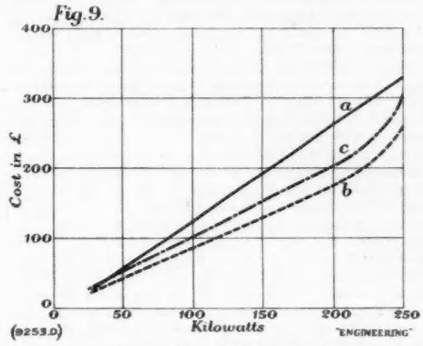


Fig. 9.



Vane control can be used when normal output regulation of the fan is considered sufficient. This combines the advantages of constant speed with simplicity. The fan is driven by a single- or two-speed squirrel-cage motor, the output being controlled by changing the constant-speed characteristic of the motor. This change is effected by creating and varying a swirl in the direction of rotation and concentric with the wheel by means of pivoted vanes at the fan inlet. A new constant-speed characteristic is obtained for each position of the vanes. Where a very wide speed range is essential, commutator motors operating in conjunction with induction regulators should be used. The control is stepless and while the normal speed range is 1 to 4, machines can be designed with a range of 1 to 10. The connections of such a motor are shown in Fig. 4.

One of the major problems, when the available supply is alternating current, is the selection of a suitable drive for the windlasses, capstans and cargo winches. Neither the squirrel-cage nor the wound-rotor motor can emulate the high performance of direct-current for these purposes. Direct-current can, however, be obtained either from motor-generators, as shown in Fig. 1, or by coupling direct-current generators in tandem with the main alternators. Alternatively, alternating current commutator motors with a series characteristic can be employed. This will provide the necessary speed range of 1 to 4 and, if required, a maximum light-hook speed can be obtained by incorporating a four-pole winding in conjunction with a load discriminator. The motor connections can be changed to give a shunt characteristic in the lowering direction. Stepless control can be provided by an induction regulator, or a transformer with primary tapping can be used to give a limited number of steps. The connections for this motor are given in Fig. 5.

At the present time, the motors used on large refrigerating compressors are of the slow-speed type with a speed variation of about 50 per cent. Neither squirrel-cage, wound-rotor or commutator motors are suitable for this duty and the only solution, apart from retaining the direct-current drive, is to use a squirrel-cage motor in conjunction with what is known as "speedmaster" control. This consists essentially of a single unit machine which is controlled by an induction regulator as shown in Fig. 6. This control is similar to that used on shunt and series variable-speed commutator motors and the induction regulator gives stepless control and quick acceleration. The disadvantage of this drive is that it is expensive. Two-speed change-speed squirrel-cage motors should be installed for driving refrigerator cooler fans and, where so desired, for operating the ventilating fans in the machinery and accommodation spaces. They may also be used for driving centrifugal pumps where the lower speed is an advantage. For these services, the two speeds should be full and two-thirds speed. As two stator windings are necessary, the cost of such a motor is higher than that of the constant-speed squirrel-cage motor. Owing to the necessity of conserving cargo space, the refrigerating cooler fans are usually placed so that they cannot be inspected until the cargo has been discharged and the spaces thawed. For this service, squirrel-cage motors are therefore eminently suitable, owing to their simplicity and robustness; and one installation, using a frequency of 100 cycles per second, has been completed for a British shipowner. Manufacturers are, however, confident that they can design fans to operate from a 50- or 60-cycle supply.

Where it is necessary to limit the magnitude of the starting currents of motors operating from the emergency supply in order to avoid overloading the emergency generator, wound-rotor or high-torque low-starting-current squirrel-cage motors should be installed. For direct-drive steering gears wound-rotor motors with secondary resistance starting should be fitted, but for electro-hydraulic steering gears ordinary squirrel-cage or high-torque low-starting-current squirrel-cage motors with direct-on or star/delta starting are best. The type of motor and the method of starting depend on the relative rating of the motors and the emergency generator. The same consideration applies in the case of the motors driving the boat winches, though usually the high-torque motor with direct-on starting will be found suitable. The motors driving the fire and bilge pumps, which are only required to start against a small percentage of the full-load torque, may be either of the ordinary squirrel-cage type with star/delta starting or of the high-torque squirrel-cage pattern with direct-on starting.

Distribution conditions on board ship are entirely different from those encountered on land. The lighting network should be supplied through a number of separate feeders from the main switchboard and the voltage fluctuation with direct-on starting of squirrel-cage motors should not, therefore, be so pronounced as when a combined lighting and power load is supplied through the same feeder. The rating of the motors in relation to generating capacity will, however, limit the size of the motors which can be started direct. This must be taken into consideration when estimating the number and rating of the generating sets, a small number of large-capacity generators being more economical, both as regards their own first cost and that of the motor control equipment. The starting current of a single motor should not generally exceed 50 per cent. of the normal rating of one generator, though this figure need not be strictly adhered to. In selecting the control gear, the percentage of full-load torque against which the motor has to start must be considered. With the exception of the smaller domestic appliances, the majority of the power drives have a very low frequency of starting; fan, pump and steering-gear motors invariably running from port to port. The majority of motors, too, are only required to start against a small percentage of full-load torque and are rated so that direct-on switching can be used.

Domestic services consist of cooking, heating and lighting circuits, the limiting voltages being 250 volts for cooking and heating and 150 volts for lighting. The loading of individual cooking and heating apparatus can be comparatively high and care should be exercised to ensure a reasonably balanced three-phase load. With the three-phase three-wire system, a three-phase supply can be given to each item of equipment when the loading is high. With a three-phase four-wire system, whether the neutral is earthed or not, the various loads should be as nearly balanced as possible between the three phases and neutral. All the equipment should be permanently wired and all the metal work, other than that designed to be alive, should be efficiently earthed. On the larger vessels, the most economical use of copper will be obtained by supplying the heating and ventilating loads as far as possible through the same distributors, as at times of maximum fan load there will be no heating load, while at times of maximum heating load the fan load will only be about one-third its maximum.

The lighting load on a modern passenger vessel may be 500 kVA or more, and when planning the layout care must be taken to avoid any undue out-of-balance. The cabin accommodation presents the greatest difficulty as one particular side or section of the vessel may be found to be more favoured than others. In such cases not only should each section of each deck be balanced, but also each side of each deck. While the present regulations limit the voltage for lighting circuits to 150 volts, it could, except for a few special applications, be raised to 230 volts in the case of a three-wire three-phase 400-volt system, with transformers for supplying the 230-volt circuits, and with a three-phase four-wire system with earthed neutral. In a three-phase four-wire insulated neutral system, an earth on any one phase would result in the full 400 volts between the remaining two phases and earth, with the increased risk of shock from accidental contact. If the voltage is raised to 230, particular attention must be paid to the earthing of all metallic fittings, as required by the regulations, and all socket outlets for portable appliances should be of the three-pin shutter type. Fluorescent lighting is advantageous for use in air-conditioned spaces, as the heating effect is only one quarter of that with incandescent lighting of the same intensity.

In order to eliminate any interference with the equipment, the power supply to the radio room should

be taken directly from the main switchboard and be kept remote from all other cables. No cables, other than those for supplying the equipment, should pass through the radio room. The effect of radiated interference will be reduced if the bulkheads, deck and overhead of the room are of steel. Where the room is a wooden structure, the cable runs should be arranged so that at least one steel bulkhead or deck intervenes between them and the radio equipment. Only those items of equipment actually creating radio interference should be fitted with suppressors.

Figs. 7 and 8, on page 215, show the relative costs of Diesel-driven and turbine-driven direct- and alternating current generators, while Fig. 9, curve *a*, shows the costs of cables for the 220-volt direct-current, curve *b* for the 440-volt three-phase three-wire, and curve *c* for the three-phase four-wire systems of distribution for various loads to be transmitted 50 yards, that is, 100 yards lead and return in the case of the direct-current system. The cable costs are based on the use of hard-rubber single-core for the direct-current and three- and four-core lead-covered armoured and braided cables for the three-phase systems. While appreciable economies can be effected on generating plant, motors, control gear and cables, these will be offset to a greater or less extent by the number of wide-range variable-speed motors installed and the capacity of the transformers. On the basis of cost alone, it is prohibitive to install variable-speed alternating-current commutator motors in their present stage of development for cargo-working machinery; and it would appear that for all-round economy and reliability the ship's electrical installation should be composite, the direct-current supply for the deck machinery and refrigerating-compressor motor being obtained either from rectifiers, motor-converting plant, or direct-current generators in tandem with the main alternators. With a three-phase four-wire system, the transformer capacity will be limited to that required for lighting, although with a three-phase three-wire system it would have to be sufficient to cater for the heating and cooking services as well.

While it is impossible to make any firm comparison of costs between the direct- and alternating-current systems for all classes and types of vessel, investigations carried out on three classes show that, for connected loads of 5,000 kVA and less, the system of distribution should be three-phase four-wire with an unearthed neutral, direct-current generators in tandem with the main alternators being used to supply the deck machinery and refrigerating-compressor motors. For higher loads either the three-phase three-wire system with transformers for supplying the lower-voltage circuits or the three-phase four-wire system should be employed. In both cases, direct-current generators in tandem with the main alternators should be installed for supplying the deck machinery and refrigerating compressors.

Maintenance costs are affected by the type of distribution system employed, and the installation of the correct equipment, as well as by efficient supervision during manufacture and the qualifications of the operating personnel. The possibility of utilising the squirrel-cage motor for the majority of drives is an important feature in reducing maintenance owing to the elimination of commutators and brush gear. It has been argued that to alter the voltage from 220 volts direct to 400 volts alternating current would increase the number of insulation failures. There is, however, little justification for this view, as provided the design is correct, such failures are usually the result of creepage paths. Maintenance costs should also be further decreased owing to the reduction of electrolytic action, particularly on the smaller branch wiring circuits.

CLOSING DOWN OF METAL-RECOVERY DEPOT.—The Minister of Supply announce that the recovery of secondary aluminium ingot from crashed-aircraft scrap, which has been carried on since 1943 under the management of Messrs. Morris Motors, Limited, at No. 2 Metal and Produce Recovery Depot at Eaglescliffe, County Durham, will cease, at that depot, at the end of March or the beginning of April. It is expected, however, that the salvage and disposal of other aircraft material, now lying at the depot, will continue for some months.

YORK-NORTHALLERTON TRACK IMPROVEMENTS.—Sir Cyril Hurcomb, chairman of the British Transport Commission, has announced that consideration is being given to a plan for constructing additional tracks, where necessary, to provide the North Eastern Region of British Railways with double tracks in each direction on the main line between York and Northallerton. The scheme also includes the installation of three- and four-aspect colour-light signals of the automatic and semi-automatic searchlight types, and the construction of a new bridge over the River Ouse at Skelton. The cost is estimated at 377,000*l*. In addition to heavy passenger traffic, the line carries the North Eastern Region freight traffic between Scotland, Tyneside and Tees-side, and the South.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

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Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.

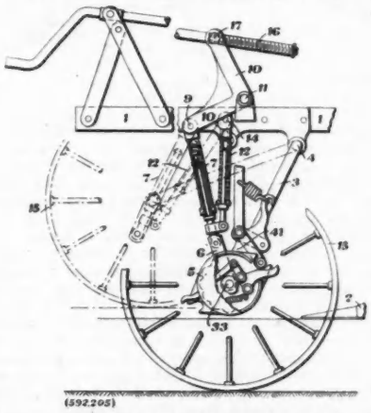
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AGRICULTURAL APPLIANCES.

592,205. Lifting Mechanism for Plough. Ransomes, Sims and Jefferies, Limited, of Ipswich, and A. Challacombe, of Ipswich. (7 *Figs.*) March 7, 1945.—The invention relates to lifting mechanism for multi-furrow tractor ploughs, and its object is to ensure that there shall be a constant maximum clearance between the plough bodies and the ground when the beam is lifted, irrespective of the depth of ploughing selected. The beam 1, which carries the plough bodies 2 (only one of which is indicated) is provided with the usual crank axle 3 pivoted to the beam at 4, its cranked end taking a socket 41 in which a stub axle 33 can rotate. A land wheel 15 is mounted on the stub axle 33 and has a lifting clutch 5 and lifting crank 6. A main connecting rod 7 has an upper end engaging with a pin 9 on one arm of a bell-crank lever 10 which is pivoted to the beam 1 at 11, about which point it is adjustable by a screwed shaft 16 engaging in a nut 17 to regulate the depth of ploughing. The lower end of the connecting rod 7 is pivoted



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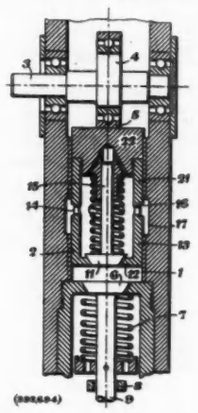
to the crank 6 which is integral with the axle 33. The lower end of an auxiliary connecting rod 12 is pivoted to the crank 6, while its upper end engages with a pin 14 on the beam 1 in front of the pivot 11. The lost-motion connection, permitting the co-operation required between the rods, is provided by constructing the rods of telescopic form as shown. When the beam is to be lowered, the clutch 5 is tripped to engage the crank 6 which, as the land wheel 15 advances, is rotated through 180 deg., when the clutch again releases it. At the beginning of the movement of the crank 6, the auxiliary rod 12 supports the load. Soon after the crank 6 begins to rotate, the main rod 7 takes over the load for the lowering of the beam. When the beam is to be lifted again, the trip is operated to allow the clutch to engage the crank 6, which is revolved by the land wheel through another 180 deg. until it reaches its highest position and the clutch again releases it. During the lift, the load is first taken by the main rod 7 and afterwards by the auxiliary rod 12 until it has raised the beam to the maximum height. (*Sealed.*)

HYDRAULIC APPARATUS.

592,694. Reciprocating-Piston Pump. Precision Developments Company, Limited, of London, and G. Olah, of London. (1 *Fig.*) May 31, 1945.—The present invention relates to reciprocating pumps of the kind used for the supply of liquid under high pressure, its object being to attain a high degree of volumetric efficiency. Each cylinder 1 is provided with a piston 2 of substantial length. A camshaft 3 is mounted above the cylinder and arranged to reciprocate the piston by means of an eccentric 4 through a ball bearing 5. Practically the whole bottom of each cylinder is constituted by a mushroom-type inlet valve 6, which is normally held on its seat by a light spring 7, but will open under a very slight difference in pressure when the piston 2 moves for its suction stroke. A movable abutment 8 is arranged to co-operate with the stem 9 of the valve 6, in such a manner as to lift the valve from its seat either during the suction stroke only, or also during part of the delivery stroke under certain conditions. The piston 2 is made in two parts 21 and 22. Part 21, which forms the front of the piston, consists of a seat 12 for the outlet or delivery valve 11 and a lateral wall portion 13 provided with port openings 14 at a suitable distance from the front of the piston. The back part 22 seals the delivery valve chamber at its back



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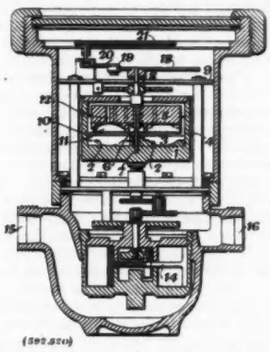
end and also acts as a guide for the stem 15 of the delivery valve. The ports 14 in the wall 13 of the piston shell end in a groove 16, which surrounds the piston shell, while another groove 17 is provided in the cylinder wall and arranged to communicate with a delivery passage in the cylinder block; the width of these two grooves 16 and 17 is arranged to be sufficient to ensure communication of this delivery passage with the port openings 14 in the piston wall throughout the stroke of the piston 2. The length of the piston shell can be made sufficient to avoid appreciable leakage from the annular delivery chamber surrounding the piston. (*Sealed.*)

MISCELLANEOUS.

592,520. Liquid-Drag Speedometer. George Kent, Limited, of London, and H. G. Flory, of Luton. (5 *Figs.*) April 16, 1945.—This invention relates to a liquid-drag speedometer, one application of which is the measurement of the rate of flow of a fluid. The primary object of the invention is improved reliability and accuracy. In the illustration, 1 is a rotor having a recessed upper surface 2 with eight upstanding radial blades 3. The rotor is formed with a cylindrical wall 4 for containing a body of mercury. 5 is the stator carried by a spindle 6, pivoted at the bottom in the rotor at 7 and at the top in a hole 8 in a plate 9. The underside of the stator is recessed at 10 and is formed with nine blades 11 extending downwards. Air-vent passages 12 lead through



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the stator from holes in the uppermost parts of the recessed underside of the stator. The rotor 1 is driven through a train of gearing from a rotary impeller 14 driven by the flow of fluid from inlet 15 to outlet 16, the rate of flow of which is to be measured. The particular means for deriving rotary motion from fluid flow is of known nature and forms no part of the invention. The stator 5 is biassed by a hair-spring of a strength suitable for controlling the amplitude of angular displacement of the stator under the conditions of operation. The upper extremity of the stator spindle 6 carries a cam 18 acting on a roller 19 on the end of an arm 20 directly connected to the spindle of an indicator 21. Sufficient mercury is placed within the cylindrical wall of the rotor to bring it to such a level that the stator is just buoyant, so that its weight does not bear on the bottom pivot 7. (*Sealed.*)